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Brain and Memory

The brain breathes mind like the lungs breathe air.

—HUSTON SMITH, *FORGOTTEN TRUTH*

THE MYSTERY

Our brain. It lies behind the creativity within the Sistine Chapel and the formu las of Einstein. It has taken humankind to the moon and will someday reach th stars. Perhaps only the universe itself can equal its marvel, yet we know so litt of it. How can this physical organ create a private mental world that has no mas and no spatial location? Where are our thoughts? How are they generated by ou brain? How has our identity become intricately enmeshed within it? These ques tions we cannot yet answer, and we leave them to the philosophers and neuro scientists of the future. Here we take a brief, pragmatic look at what we do kno about the brain, particularly how it affects our thinking, for though the brain i still a great mystery, we have begun to learn its secrets.

We have also begun to learn the secrets of memory—but only begun. Thi mystery within a mystery is the bedrock of thinking itself. It, too, has its point of wonder. How is it, for example, that a physical process in the brain can giv rise to the memory of your grandfather? If you could take a journey inside you brain, where would he be found? While we can't answer this question, it is worth while to think about it, for the activity of thinking enhances thought, just as th activity of memory enhances memory, as we will discuss below.

In what follows we look at the brain, its universe of neurons, the influences on the brain that affect our thinking, and ways to move our brain toward better thinking. We then explore memory, its impermanence, the reasons why we forget, and how we can remember better. With this understanding of our brain and memory, we can lay a stronger foundation for critical and creative thinking.

THINKING AND OUR BRAIN

As you read these words your brain is at work. Relying on earlier learning which associated certain line patterns with letters of the alphabet, your brain checks its own database for familiar combinations of these letter patterns and then recognizes the words or word phrases as individual units. Unfamiliar words, like "phacoemulsification" are flagged and processed with greater attention to each letter or syllable. As all of this is taking place your brain is simultaneously placing these words and word phrases in a context that gives them meaning; the words make sense. Your brain may then continue on to yet another step as you think about the meaning of the sentences themselves. For example, you might wonder about the complexity of this process, the fact that you have little control over it (try not to see the letters as words, for example), or whether there can be any kind of thinking without the brain (as in speculations about an afterlife). As you continue to process these words, you might also judge the value of this information, compare it with other information you already have, or wonder about the point the authors are making. You might even think about whether a machine could ever be developed that can do what you are doing now. All this wondering, valuing, and organizing is done with your brain. Alter the brain or destroy it and the character of this process changes or ceases altogether.

The brain is incredibly complex and has the potential to handle huge thinking demands. It contains more than one trillion cells, about 100 billion of which are neurons. These neurons are the single-cell messengers that carry out the responses that comprise our thinking and movement activities. It would take you about 4,731 years to count them all if you counted one number per second every minute of your waking life! But that's just the beginning, for each of these 100 billion neurons has 1,000 to more than 200,000 contacts with other neurons, each neuron sending and receiving messages up to 1,000 times a second. With this incredible, dynamic interconnectedness, the number of different pathways in the brain is unimaginable!

What we consider to be critical thinking ability is located in the outer part of the brain, that wrinkled cap called the cortex. The cortex is about one-tenth of an inch thick and is convoluted, which explains how its one and two-thirds square feet of surface area can fit within the confines of the human skull. The cortex alone contains more than 10 billion neurons. In one square inch of this

cortex there are about 10,000 miles of nerve cell connections! In the entire cortex, if we layed these connections out end to end, they would stretch to the moon and back to earth—and then to the moon again! (Davis, 1984). It is here, in this incredibly expansive cortex, that all the higher intellectual processes take place. The rest of the brain is responsible for lower functions, such as emotions, hunger, and basic life-sustaining processes, although even these are influenced by input from the cortex.

We are still in our infancy in understanding how our brain's universe of neurons interact to create thinking, but we have made some significant progress. We know, for example, that brain neurons do not touch; they communicate by sending a tiny amount of a chemical substance called neurotransmitter across a synapse, the microscopic space between adjoining neurons. Fifty-three different types of neurotransmitters have been identified so far (Ratey, 2001), with perhaps hundreds waiting to be discovered. The balance between these neurotransmitters is rather delicate. A glass of wine, a strong cup of coffee, a poor night's sleep, a candy bar, or a common cold pill can affect it. Even falling in love can change the chemistry of the brain. When this chemistry changes, the way we perceive and think about reality changes too. Below we briefly address some of the variables that can impact the brain in a way that affects our critical thinking abilities.

THINKING ACTIVITY 4.1
An Exercise in Mental Discipline

Do you agree with the Eastern analogy of the mind that thoughts jump hither and thither like monkeys jump from tree branch to tree branch? To check out this "monkey mind" analogy, try a simple meditation exercise for ten minutes. Sit in a comfortable chair in a quiet room and try to keep your attention on only one thing, like an inner image of a candle flame, the sound "ah nam" silently repeated to yourself, or a blue vase. When you find yourself thinking about something else, bring your attention back to your object of meditation. After doing this exercise, what do you think about the extent to which you consciously control your thinking?

Food and Drugs

O God! that men should put an enemy in their mouths to steal away their brains.

—SHAKESPEARE

Clearly the brain needs food. Like the rest of our body, it requires energy, specifically glucose, which it gets from the body's conversion of starches and sugars. Like the rest of the body, the brain also needs protein and vitamins for proper functioning. Without adequate nutrients, intellectual impairment results:

In an intensive study of the children of North American Indians, Dr. Ernesto Pollitt, of the Massachusetts Institute of Technology, demonstrated a 50 percent decrease in behavioral performance in severely malnourished children. Memory, abstract reasoning, thinking, and verbal ability were most affected. (Restak, 1979, pp. 107–108)

But we do not have to be malnourished to notice the effects of nutritional iency on our thinking. Simply trying to go through the day with too few ies impairs our ability to concentrate, as any student knows who has tried ncentrate on a lecture on an empty stomach.

Of particular importance to thinking are the B vitamins. Vitamin B defiy has been linked to problems in memory, concentration, and depression. ıte cases of vitamin B deficiency, particularly thiamine, Korsakoff's syne may develop. This is a chronic disorder, even after the vitamin deficiency rected, which creates gross deficits in short-term and long-term memory. leficiency is particularly a problem with alcoholics, for alcohol rapidly de- the body of essential B vitamins.

Besides depleting the body of vitamin B, alcohol also impairs our thinking, ularly judgment and decision making, through its intoxicating effects. ; prolonged drinking changes brain tissue and may permanently retard inual abilities. Specifically, it can retard problem solving, impair learning and tion, and reduce attention. These effects are due to the underlying brain e inflicted by chronic alcohol abuse. This damage occurs because alcohol res with neurotransmitters, kills brain cells, causes neuron atrophy and in- growth, and shrinks the brain (Oscar-Berman et al., 1997 and Barinaga, Areas that are targeted include the limbic system, responsible for memod the cerebral cortex, where our higher thinking activities occur (Oscarn et al., 1997). Though not everyone responds to alcohol in the same way, re alcohol one drinks, the more likely these pernicious effects will occur.

nk About It: ***It is common knowledge that women who drink while nant can cause their baby to be born with fetal alcohol syndrome, a syne involving mental retardation and facial and limb abnormalities. Yet, ac- ng to a 1996 report (cited in Barinaga, 2000), 20 percent of women who alcohol continue to drink while they're pregnant! Does this show the r of addiction over sound thinking? Or is there another explanation? t do you think?***

sides alcohol, another legal and very popular drug in the United States ne. Nicotine is most commonly absorbed through cigarette smoking. on the effects of smoking on memory and learning are mixed. Some have

found that smoking enhances learning and memory, especially short-term recall; others have found it to have a deleterious effect. Reviews of some of these studies (Adler, 1993a; Bower, 1993) suggest that the positive effects of smoking on learning and memory seem to pertain only to simple memory tasks, and these positive effects may benefit only those who are already addicted to nicotine. Regarding more complex memory and learning tasks, however, nicotine has been found to be detrimental, decreasing logical reasoning abilities, impairing performance on complex memory tasks, reducing problem-solving ability, and adversely affecting recall of critical information in essays. Similar effects are experienced during nicotine withdrawal and may linger for one to two months afterwards (Adler, 1993b). While researchers are continuing to explore the possible learning and memory enhancements of nicotine, they seem to agree that cigarette smoking's potential for harm far outweighs any memory and learning enhancement so far discovered.

Marijuana is the most popular illicit drug in the United States. One animal study found that chronic exposure to moderate levels of THC accelerated brain-cell death in the hippocampus, a very important brain structure for long-term memory formation (Landfield, Cadwallader, and Vinsant, 1988). A later study found that heavy marijuana use reduces attention and learning abilities (Pope and Yurgelun-Todd, 1996). This is consistent with earlier research that has found attention deficits and decreased motivation among regular marijuana users. Even occasional use of marijuana harms thinking. Marijuana intoxication retards learning, inhibiting the transfer of information from short-term to long-term memory. Thus, students who study while smoking marijuana are wasting a lot of their time! And though marijuana smokers believe it enhances their creativity, one study found that in fact it does not (Tinklenberg et al., 1978).

Another drug that can affect thinking is cocaine, a stimulant that, taken daily in large doses, can produce irritability and disturbed concentration. With chronic, heavy use it can lead to paranoid thinking and perceptual disturbances (Grinspoon and Bakalar, 1985). Even those who never ingested cocaine may suffer its effects if they were exposed to it in the womb. Research with humans and animals have found that prenatal exposure to cocaine has subtle but significant effects after birth, such as concentration difficulties and greater susceptibility to distractions. Animal research suggests that these effects are due, at least in part, to abnormal growth of brain neurons (Vogel, 1997). Brain abnormality of those prenatally exposed to cocaine is also suggested by research that has found a difference in EEG measures in infants who were prenatally exposed (Scher, Richardson, and Day, 2000). Research in this area is challenging and not all conclusions are consistent (e.g. Hurt and Malmud, 1997), but apparently, cocaine is not a brain-friendly drug.

Other commonly abused drugs, also of the stimulant class, are the amphetamines. These drugs are commonly used to maintain wakefulness and alert-

ness or to increase metabolism and suppress appetite. Although they do have these effects, in heavy use over several days they can cause paranoid delusions, hallucinations, irritability, and insomnia—and distortions in thinking and social functioning that result from these effects. A drug user's "irritability and paranoia may cause fights and unprovoked violence and drive their friends away; their preoccupation with the drug has a disastrous effect on their family relationships and work" (Grinspoon and Bakalar, 1985). When discontinued after prolonged use, they can lead to depression and even suicide.

All of these drugs interact with the brain at the synapse, increasing or decreasing the brain's natural chemical activity. Even though their pharmaceutic effects are different, they all have in common the ability to disrupt our cognitive abilities.

Think About It: ***Many people considered to be very brilliant, some to the point of genius, developed ideas and theories that conflicted with those of other very brilliant persons. For every brilliant determinist we can find an equally brilliant proponent of free will; for every empiricist, a rationalist; for every pessimist, an optimist; and for every theist, an atheist. In one sense almost all of them are mostly or entirely wrong, assuming there can be only one correct view. That being the case, what is our basis for considering these people to be extraordinarily brilliant?***

Sleep

We need sleep to think; perhaps that is why we spend one third of our lives sleeping. The important stage of sleep for critical thinking is the REM (rapid eye movement) stage, during which dreaming occurs. When people are more intellectually active during the day they dream more (Smith and Lapp, 1991), and when they are deprived of dream sleep, they have cognitive impairments, such as reduced memory capabilities (Li et al., 1991; Drummond et al., 2000) and impaired concentration (Horne, 1985). These studies and others (e.g., Louie and Wilson, 2001) suggest that dreams are crucial for solidifying learning that takes place during the day and that our daily sleep is necessary for optimal cognitive functioning.

So how much sleep should we get each night? One Study using college students found that only those who slept at least six hours improved on a learning task, and those sleeping eight hours improved the most (Blakeslee, 2000). Most people will need much more than six hours for optimum cognitive functioning. Some researchers are now recommending between nine and ten hours (Brownlee, 1999a; Coren, 1996), which is closer to our ape cousins. This may be more true for teenagers and young people in universities who are going through more biological changes and pushing their cognitive resources with brains not yet fully developed, than for older adults. And though we may "get by" with less sleep, we will still suf-

fer the consequences of sleep deprivation. Sleep debt can negatively affect mood, motivation, memory, decisionmaking, concentration, problem solving, and logical thinking (Coren, 1996). One sleep expert estimates that for teenagers those consequences translate to a loss of one IQ point per day for each hour lost under eight hours of sleep—accumulating throughout the week! (Brunet, 1997). Fortunately, he also believes the loss can be recovered by sleeping on weekends. Time for a nap?

Think About It: ***The lowered reasoning ability of people with a sleep debt has been taken advantage of by professional negotiators who intentionally keep their parties up very late at night and continue the meeting early the next morning. One negotiator admitted to keeping the caffeinated coffee available all night to further reduce their sleep. In the end, an agreement is more easily reached because parties get sloppy, forget the details, and lose their motivation to fight over anything but the major issues (Coren, 1996). Is this ethical?***

THINKING ACTIVITY 4.2
Critical Reading Before We Sleep

To illustrate how mental fatigue can hinder critical thinking and concentration abilities, read the following passage on the unconscious by C. G. Jung and the poem by Emily Dickinson just before you fall asleep, or during some other period when you are mentally fatigued. (Don't do it now!) Then, shortly after you awake, read them again. Granted, you are reading them for the second time and may understand them better because of that, but you should also notice the difference between your ability to concentrate the first time as opposed to the second. How does your first reading compare with your second?

The Passage from Carl Jung

We cannot overlook the fact that, just as consciousness arises from the unconscious, the ego-centre, too, crystallizes out of a dark depth in which it was somehow contained in potentia. Just as a human mother can only produce a human child, whose deepest nature lay hidden during its potential existence within her, so we are practically compelled to believe that the unconscious cannot be an entirely chaotic accumulation of instincts and images. There must be something to hold it together and give expression to the whole. Its centre cannot possibly be the ego, since the ego was born out of it into consciousness and turns its back on the unconscious, seeking to shut it out as much as possible. Or can it be that the unconscious loses its centre with the birth of the ego? In that case we would expect the ego to be far superior to the unconscious in influence and importance. The unconscious would then follow meekly in the footsteps of the conscious, and that would be just what we wish. (Jung, 1983, p. 218)

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THINKING ACTIVITY 4.2 (continued)
Critical Reading Before We Sleep

Now read this untitled poem by Emily Dickinson (*Selected Poems*, 1924, pp. 223–24).

I heard a fly buzz when I died;
The stillness round my form
Was like the stillness in the air
Between the heaves of storm.

The eyes beside had wrung them dry,
And breaths were gathering sure
For that last onset, when the king
Be witnessed in his power.

I willed my keepsakes, Signed away
What portion of me I
Could make assignable,—and then
There imposed a fly

With blue, uncertain, stumbling buzz,
Between the light and me;
And then the windows failed, and then
I could not see to see.

Our Thinking Potential

If we avoid the substances and practices that can dull our thinking, and work positively on the suggestions in this book to sharpen our thinking, we can begin to fulfill our own unique potential to think. Our brain *can* be moved toward greater thinking.

For our thinking to grow, our brain must grow. Like a muscle, it must be worked to reach its maximum capabilities. Without intellectual work and stimulation, our minds will not develop to their potential. Ideally, this stimulation should begin during the first three years of life. Talking to infants might be the best kind of stimulation they can receive at that young age. But stimulation shouldn't stop there! New research is finding that the human brain grows dramatically through the first fifteen years, and then slows just as dramatically after that. From ages three to six, parts of the brain involved in planning and organizing new actions and in maintaining attention develop most rapidly. From ages six to puberty accelerated growth shifts to the areas involved in language and spatial relations (Thompson et al., 2000). The brain doesn't complete its basic hardwiring

until the early twenties! (Brownlee, 1999b). Enjoying a robust environment during these formative years will help the brain reach its thinking potential.

Many studies have shown the effects of environmental stimuli on intellectual development. Some of these studies involved orphaned and other children who were raised in a sterile, impoverished environment. Other studies used rats in an experimental design in which some were raised in a rich, complex environment and others in a sterile one. What these studies find is that a rich, stimulating environment is necessary for the actualization of the brain's intellectual capacity. Raise an organism in an intellectually unchallenging environment and its intelligence becomes stunted.

While it is best to nourish the brain when young, the good news is that even as adults we can improve our brain. One study found that even aged rats who had lived all their lives in a sterile world could benefit from a stimulating environment (Greenough, 1988). Put in a world with mazes, bridges, and spinning wheels, these rats developed an average of 2,000 new synapses *per neuron!* It would be unethical to perform such a study with human beings, of course, but the implication of this research is that it may never be too late for us to start growing toward our potential. And if that isn't enough to motivate us to use our mind, consider this: studies (e.g., Gagnon et al., 1990) have found that the longer we stay intellectually active, the less chance we have of developing dementia, a brain disease that insidiously degrades intellectual functioning. Do you feel like reading a book about now?

If we get our sleep, avoid drugs including alcohol, eat right, and stimulate our brain with intellectual activity, we may expand the potential of our brain. But does the nature of our brain limit our understanding of the world? It probably does, although it is difficult to know the extent to which it does. The situation is something like a blind man trying to know a world of colors and light, which he cannot experience.

If we reflect for a moment on our experience, we can see that we have only five senses that feed our brain the information we use to think. It is possible that there are six, seven, or a hundred ways to experience the world. We have no reason to suppose that we possess all the senses necessary for a complete understanding of the universe. Even the experiences we are given with our senses may not represent the true reality. Is your pen really blue? Or is that blueness just the relationship between your pen and your sense organs, the way your brain processes those sensory data? Does the colorblind man see it wrongly or just differently? Do we have sufficient justification for believing that our brain and sense organs bring the "real" world to us? Could it be that our brain structures reality as much as it discovers it? The philosopher Immanuel Kant believed that causation, space, and time are structures imposed upon the world by our brain. The Oxford mathematician Roger Penrose (1989) takes a similar view:

> The "time" of physical descriptions does not really "flow" at all; we just have a static-looking fixed "space-time" in which the events of our universe are laid out! Yet, according to our perceptions, time *does* flow. My guess is that there is something illusory here too, and the time of our perceptions does not "really" flow in quite the linear forward-moving way that we perceive it to flow (whatever that might mean!). The temporal ordering that we "appear" to perceive is, I am claiming, something that we impose upon our perceptions in order to make sense of them in relation to the uniform forward time-progression of an external physical reality. (p. 444)

In sum, our brain, as healthily as we might maintain it, probably limits our ability to perceive and think about the world. It is likely that if our neurons fired faster, if they were organized differently, or if our brains were slightly larger, our experience of reality would be quite different than it is today. Thinking is not perfect thinking that yields absolute truths about reality, just the best sound thinking we can do with the brain instrument we are given.

Think About It: ***We know that drugs can alter our perception of reality and distort our thinking. Yet the brain is also a drug machine in its normal state. Does the normal "drugged" state of the brain limit and distort our thinking too? What state of the brain gives us a "true" picture of reality?***

Brain and Mind

One of the most important philosophical problems concerns the relationship between the brain and the mind, known as the *mind-body problem*. There are two fundamental (and related) questions here: (1) are the brain and mind separate entities? (2) in what way are brain and mind related? The brain is rather simply defined as the physical organ or mass of nervous system tissue enclosed by the skull. Most people know to what we refer when we speak of the brain. There is less agreement, however, about the definition of mind. It is not the physical organ under our skull that we refer to when we speak of our mind. Rather, *mind* is normally defined as the organized structure of our mental processes, including remembering, thinking, perceiving, and experiencing. Sometimes it is seen as synonymous with consciousness, but then what of the unconscious? Is that not part of the mind? One might say that the neuron is of the brain, but our memories of first grade are of our mind, part of our mental world. But what is that mental world? Is it merely a property of the brain? Is it generated by the brain? Or does the brain simply receive mind and interpret mind, much like a radio station receives radio signals? Does the mind drive the brain? Or does the brain drive the mind? Can mind exist at all without the brain? If so, what is its nature without a brain, and how do we account for the apparent connection between the two such that a change in brain tissue seems causally related to a change in mental experience?

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Brain and Mind ***(continued)***

Interestingly, the brain and the mind seem to have different properties. The brain has mass, is public (everyone can see it during an autopsy), and is located in space. Our mental world, however, is private (no one knows what you're thinking), has no mass, and is not located anywhere in space (so far as it appears). When we refer to our memory of our grandfather, we don't equate it with the sequence of neuron firings that occur during our recollection. So how can a brain, which has properties that our mental life does not, and does not seem to be the same as our mental life, give rise to mind? Or vice versa? Are brain and mind two aspects of something else? Is matter an illusion? (It does seem to disappear as our exploration of it deepens.) Or is mind somehow a form of matter?

Finding the answers to these questions will help to solve other important philosophical problems like determinism versus free will and the possibility of survival after death. There are good arguments on many sides of this mind-body issue, but none has provided a definitive conclusion.

In this chapter we have used statements like "Our brain can be moved toward greater thinking" and "For our thinking to grow, our brains must grow." Obviously these statements could be challenged, depending on one's point of view on mind-brain relationship. It is difficult to satisfy all theoretical points of view on this issue, and we do not mean to support any particular theory of mind.

THINKING AND MEMORY

> *The past is what you remember, imagine you remember, convince yourself you remember, or pretend to remember.*
>
> —HAROLD PINTER, PLAYWRIGHT

Without at least some brief memory, we could not think. For even adding the numbers 6 and 3 requires memory of 6 as we add to it 3. Without memory there could be no thinking based upon experience and there would be no continuity to our world. We would be fully immersed in the present and have no future to imagine, no past to consider. We wouldn't know who we were or where we were going. Being conscious in this perpetual present seems conceivable to some, but thinking in it seems unimaginable.

Thinking and memory are inseparable. What we think depends both on our ability to remember and on the content of that remembering. A poor memory or a distorted memory makes it difficult for us to think successfully. Even a good memory, however, is not perfect. In spite of how certain we may be about prior events, we can be wrong. Therefore, we must listen to the recollections of others and be open to the possibility that their stories offer a more accurate version of what we experienced. We must also back up our memory with hard data

and write down events that we know we will be expected to recollect later, and we must work actively to encode information through meaningfulness, practice, and the use of mnemonics. Below we look briefly at how memory can deceive our thinking, why we forget, and how we can improve our memory.

The Changing Nature of Memory

When memories are laid down in the brain, the neurons related to those memories undergo physical changes. Neurons branch out to make more connections, and they become able to fire more efficiently, needing less neurotransmitter stimulation. But exactly how these and other physical changes can lay down memories in the brain is still quite a mystery. What we do know, however, is that memories, no matter what their physical underpinnings, are subject to change. Before reading further about memory, take time to complete the thinking activity *Memories of Childhood* below.

THINKING ACTIVITY 4.3
Memories of Childhood

Take a moment to recollect the first time you learned to ride a bicycle or, if that's too difficult, one of the first times you rode a bicycle. Remember this in as much detail as you can before reading the next paragraph.

If your memory is an exact copy of what you experienced, then you have recalled no more than the front of your bicycle, your arms and hands on the bicycle handlebars, the sidewalk or road ahead, and some houses or trees on the side depending on where your experience occurred. If you remembered more than that and have visualized your head (which you did not see), your grandfather pushing you (whom you did not see), the rear wheel of the bicycle (which you did not see), and so on, you are adding to your actual visual experience. Almost everyone adds information to these experiences. These additions are often consistent with the *meaning* of what happened but are not perfect reproductions of the actual event.

From the above exercise it becomes clear that we actually reconstruct our memories as opposed to retrieving an exact copy of our experience. This reconstruction often, but not always, moves in the direction of the meaning of the experience. That is, although these memories are not necessarily accurate in their details, they may nonetheless be consistent with the meaning that we gave the experience. One of the earliest experiments to demonstrate this (Carmichael, Hagan, and Walter, 1932) found that if we show subjects a picture of something that looks like a very thick letter *C* or a very thin quarter-moon and tell them it's the letter *C*, they will tend to remember it

later as looking thinner, much more like the letter *C* than a quarter-moon. And when other subjects are shown the same stimulus but are told it is a quarter-moon, they later remember it as much thicker than it was, looking more like a quarter-moon. In other words, people's memories are distorted in the direction of the meaning of the stimulus, in this case the letter *C* or the quarter-moon.

The importance of meaning to our recollections of events cannot be dismissed lightly, because throughout our daily lives we continuously give meaning to the great and small experiences we endure. A dog bite might be experienced at the time as a minor nuisance but remembered as even more trivial than it was. On the other hand, if a dog bite was originally perceived as an awful ordeal, then perhaps with time our recollections of it will make it much worse than it was. The dog becomes larger, the bite more severe, the duration of battle lengthens, and the dog's owner becomes more indifferent, or even sadistic. Indeed, it appears our lives are but true tales embedded in fiction.

Think About It: *Have you ever told a story and embellished it to add more excitement to it, and then one day, as you were telling it for the tenth time, you caught yourself starting to believe the embellishments? How often do you suppose you've told such stories, failed to catch yourself slipping over the edge, and ended up believing your own created fiction?*

The memories that are most subject to change are episodic memories, which are memories of biographical events in our lives. Other kinds of memory, such as perceptual-motor memory (which is memory for how to perform skills like riding a bicycle and operating heavy machinery) and semantic memory (which includes memory of our own language, of what a dog is, and how to add numbers) are less vulnerable to distortion. But what about episodic memories of emotional events that seem to freeze time? Examples of such events are the bombing of Pearl Harbor, J.F. Kennedy's assassination, the explosion of the space shuttle Challenger, and the bombing of the Federal Building in Oklahoma City. Many Americans can recall in vivid detail where they were and what they were doing when they heard or saw the news of these events. But as we explore these memories, we find that these, too, vivid as they are, often mislead; in fact, most of our memories are quite subject to change. Some, in fact, are complete fabrications, stories that appear to come from nowhere with no grounding in facts whatsoever, yet believed to be true by the people holding them.

Experimental research has found differences among people in their tendency toward false recollections, which could be due to innate differences or variances in personal histories (e.g., Clancy et al., 2000). Despite these differences, most people are especially prone to recalling distorted or fabricated memories under hypnosis. Memories are especially vulnerable to distortion under hypnosis. Leading questions by the hypnotist or expectations of the subject under hypnosis can lead to fabricated memories. In spite of what most people think, if people undergo hypnosis to retrieve lost memories, the memories they retrieve are likely to be confabulations (false memories) instead of accurate recollections, and the confabulations revolve around the expectations of the hypnotist or the subject. Such confabulation might describe recollections of past lives and has been used to explain some false memories of incest abuse (Goldstein, 1992; Wassil-Grimm, 1995).

The following anecdote is a good example, albeit extreme, of the constructive nature and unreliability of memory. The anecdote seems to describe a reconstructed memory that is not consistent with actual events, yet the remember considers it to be true.

> The vet had come to this psychologist complaining that he suffered from constant nightmares from his years in Vietnam. He would awaken sweating, heart pounding, surrounded by images of his wounded buddies, visions of blood and gore everywhere. Unable to turn off the state of constant readiness that served him well in the foxhole, he startled at the slightest sound, reflexively reaching for his knife. During sessions the vet would cry about the buddies he'd seen murdered or would scream out in horror at a combat memory. The experienced psychologist treating him would reassure him that the war was over and he was now safe at home.
>
> Nonetheless, the vet could not be saved, and he committed suicide by inhaling carbon monoxide. Following his death, his widow attempted to get his name put on the Vietnam Memorial in Washington, D.C., since she felt he was justifiably a "casualty of the war." An extensive search of the man's military record showed that he had never set foot in Vietnam (Wassil-Grimm, 1995, p. 93).

Forgetting

Not only do memories change and impair our thinking, but we can forget them entirely. Some memories actually seem meant for forgetting, like a telephone number that we will never use again. These *short-term memories* last only about twenty to thirty seconds without rehearsal. Once they fulfill their purpose, they are forgotten and are probably not retrievable.

The memories most important for most of our thinking are our *long-term memories.* These are the memories that we need to perform well on exams, discuss the philosophy of Plato, and think critically about the world around us. Contrary to what most people believe, most of our long-term forgetting occurs shortly after learning; the rate of forgetting tapers off with time. For example, most of what we remember one year after a college course we will remember two

years later, but much of what we remember from our reading today will be forgotten in a few weeks.

Recall versus Recognition

It is much easier to recognize information than to recall it. In one study that dramatically illustrates the power of recognition (Haber, 1970), subjects were shown 2,560 photographic slides at the rate of one every ten seconds. One hour after the last picture was shown, each subject was then presented with 280 pairs of pictures. One picture in each pair was from the set of 2,560 pictures; the other was from a similar set. Each subject was asked to identify the picture that was also in the set of 2,560. What do you suppose the accuracy rate was? One might expect an accuracy rate on a recall task of this sort to be no greater than 10 percent. In this recognition experiment, however, accuracy rates were between 85 and 95 percent! This is one good reason why police departments use mug shots to help victims identify criminals. Unfortunately, we often do not have a choice about how we are to recall information. But whenever we do, the recognition option is usually more successful.

Why We Forget

Sometimes we forget because to remember would be painful. This theory of forgetting, called repression, suggests that we forget more of the unpleasant events in our lives than the good. This idea has found some empirical support through numerous case studies. Unfortunately, all of us can remember some bad events; no one knows why some negative experiences are repressed and others are not.

Another reason we forget is because other information, especially *similar* information, interferes with what we are trying to remember. This *interference theory* of forgetting explains the problems and frustrations of cramming. At the beginning of the cram session we may accurately associate names with events and theories, but as the information builds so does interference, and we often find ourselves associating names and events incorrectly. Cramming does increase learning, but because it requires more study time to overcome the interference problems, we would do better to space our study out over time.

Think About It: ***The interference theory suggests that we not study two foreign languages simultaneously. What other subjects may pose interference problems if studied concurrently?***

A third reason why we forget is because we can't find the right cues. Cues be names of categories (tools), the location in which an experience occurred ashington Park), certain smells (plum trees), and so on. Even our emotional e might serve as a cue. When we are sad we can remember sad things more ly than happy events, and vice versa (Baddeley, 1990). Why we can't retrieve right cues is unknown, but often it may be that strong, distinct cues were er associated with the information initially.

Stress is also detrimental to memory. Studies are finding that certain hornes that are increased during physical and emotional stress can impair recall. : culprits are glucocorticoids produced by the adrenal gland: corticosterone, tisone, and cortisol. One interesting study with rats found that stress in the n of electric shock interfered with the recall of memories through the effects :orticosterone (de Quervain et al., 1998). A later study with humans supted these results. Subjects were asked to memorize 60 verbs and were then :n cortisone an hour before being tested. The results: scores from the cortie group dropped by 35 percent (de Quervain et al., 2000). These findings ld explain some of the memory problems that coincide with depression and age, two conditions which correlate with higher cortisol levels. These studies y also explain memory problems of court witnesses who are under duress, or er human memory errors that occur under stressful conditions.

Think About It: ***Why is it that some students who know the material for a est cannot remember the material when they take the exam? The studies above uggest that the stress before and during the exam could interfere with a student's ecall. If so, what implications does this information have for testing students?***

w to Improve Memory

e basic strategy for enhancing our memory is to lay the information down l initially because our ability to remember is proportional to the degree which our memories were originally stored. We must not write our memo- with mere chalk; we should engrave them like a chisel on stone. We can omplish this by making the information more meaningful, by associating ormation with what we already know well, by using mnemonic techniques, l by repetition and practice.

Make Information Meaningful. Experiences that are exciting are easy to rieve because they are particularly meaningful; their memories are laid down ortlessly. Meaningful information is less likely to be forgotten than meaning- information. And though we may not find the world always exciting, we can ke it meaningful in other ways. For instance, finding the relevance of the in-

formation we are trying to learn and how it can relate to our lives increases its meaning and makes it more memorable. We can also try to understand how the information is organized or, better yet, organize the information ourselves. This provides a meaningful structure that facilitates recollection.

Information can also be made more meaningful by associating the information with what we already know well. The license number KLB100, for example, may be the initials of our name and the age we would like to live to. Noticing this relationship may make retrieval of this number effortless for months or years.

Think About It: *The fact that we can usually retrieve memories at will suggests that our memories are organized. Estimate how long it would take you to retrieve the memory of the color of your first bicycle if your memories were not organized and were retrieved at random.*

Use Mnemonic Techniques. Mnemonic techniques are strategies for encoding information so that recall is easier. One strategy uses pictures, rhymes, and associations, another uses a linking technique, and still another uses the familiarity we have with our home environment. Entertainers who impress their audience with their excellent memory usually use these and other mnemonics (see Thinking Activity 4.4).

THINKING ACTIVITY 4.4
Using Mnemonics

Following are some mnemonic techniques. These help to facilitate recall by laying down memories in an organized, meaningful manner.

Rhyme-Association Method

This is a good technique to learn if you want to impress your friends. It allows you to remember lists forwards and backwards and to identify any object associated with any of the numbers. This step first requires memorizing rhymes for each number one through ten such as the following:

One-Bun	Six-Fix
Two-Stew	Seven-Heaven
Three-Bee	Eight-Bait
Four-Floor	Nine-Dine
Five-Dive	Ten-Dog pen

Once you have these rhymes memorized, you associate the idea or thing you are trying to remember with the rhyming word. To enhance recall, these associations should be as ridiculous and lively as you can make them. For example, if you want

(continued)

THINKING ACTIVITY 4.4 (continued)
Using Mnemonics

to remember "alligator," you can imagine biting into a bun, expecting a juicy hamburger, and finding a baby alligator instead—who, much to your surprise cries, "Ouch! What do you think you're doing!" If the eighth word you are trying to remember is "rocking chair," you can imagine fishing with a rocking chair as bait.

For the numbers eleven through twenty, you can develop associations for each rhyming word in a particular setting, such as on an airplane. For eleven, you might think of biting into the bun as you hit an air pocket, for example.

Try remembering the following words with the above technique:

dust mask	stapler
computer disk	lamp
sock	quarter
batteries	address book
book	screwdriver

Method of Location

This mnemonic technique is similar to the one above; the main difference is that you do not have to memorize rhymes first. Instead, you use what you already know, such as the arrangement of your living room furniture. As you try to remember a list, mentally walk through your living room and associate each word with a living room object. In the above example, you might imagine an alligator in your houseplant playing love ballads on his guitar in an attempt to win the affection of the shark lying on your sofa.

Practice using this technique with the ten items above.

The Linking Technique

Sometimes the information we are trying to remember is difficult to picture using the above techniques. The state of Wisconsin, for example, is hard to imagine lying on the living room sofa. The linking technique may be better in such cases. In this technique, all the items to remember are connected to each other. Each item can be pictured as it is, or something else associated with or sounding like the object can take its place. For example, if you want to remember the states of Minnesota, California, New York, and Florida, you can imagine a Viking (Minnesota) standing next to the statue of liberty (New York) wearing a Mickey Mouse hat (Florida) as an earthquake (California) rocks the statue and the Viking back and forth.

Practice using this technique with the first thirteen states below. They are given in the order in which they became part of the United States of America.

1. Delaware	5. Connecticut	9. New Hampshire
2. Pennsylvania	6. Massachusetts	10. Virginia
3. New Jersey	7. Maryland	11. New York
4. Georgia	8. South Carolina	12. North Carolina
		13. Rhode Island

Think About It: *Can you think of ways to combine the mnemonic techniques above?*

Repeat. The more we repeat new information and ideas, the easier it is to remember them. College professors who have taught a course numerous times can often teach an entire semester from memory alone. But simply repeating something over and over, without attending to its meaning, does not usually work well to lay down strong memories. For instance, we could read a chapter in a college text repeatedly, but if we did not make it meaningful, organize it, or make associations with it, we would learn and remember very little. There is a place, however, for mere repetition. Poetry, for example, is learned by repetition because we are trying to recall exact words, not just the meaning. But if the poetry is not made meaningful, the words we learn are empty.

Practice. Memory can be likened to a muscle: if it is exercised it grows, if not it weakens. Putting our memory to work increases our ability to remember. As the saying goes, "Use it or lose it."

Memory Pills

We can see that laying down memories can take some serious effort. Wouldn't it be nice if we could just take a pill? Successful experiments using a "memory protein" have already been conducted with animals (Weed, 2000), so the idea that college students in the future will be picking up their memory pills along with their textbooks is not that farfetched. But how much memory is too much? Do we really want to remember the details of every bad argument, every embarrassing event, or every boring movie? What price are you willing to pay to ace that exam?

SUMMARY

The brain is our thinking instrument made up of billions of neurons in a complex connectedness that is unimaginable. For the brain to function properly, for us to reach our potential for thinking, our brain must receive adequate nourishment and sufficient sleep. It must also remain free of drugs, alcohol, marijuana, cocaine, and other substances that can affect the delicate neurotransmitter balance in the brain and lead to distorted thinking. But our brain needs more than sound nutrition and freedom from pernicious drugs, it needs stimulation. A rich, challenging environment will build our brain into a stronger thinking organ, and will help to forestall the dementias of old age. Our brain may not solve all the mysteries that concern us—and may actually create as much of the world as it discovers—but

it will give us new glimpses and new insights into our unfolding personal universe.

Hidden within our brain is our memory. We have explored some of its nature and mystery and have learned that we must listen to others who disagree with our recollections, for our long-term memory is in constant movement; it may not only revise our past, it may even create it. We've also looked at some reasons why we forget—repression, interference, loss of cues, stress, and failure to lay down memories well in the first place—and we've explored ways to enhance memory through meaning, mnemonics, repetition, and practice.

Through this greater awareness of the nature of memory, we have abandoned our absolute trust in what it presents to us. But we have also learned to improve it and move on to become better thinkers.

BRAIN AND MEMORY CHALLENGES

1. This chapter suggests that we can do a lot to maximize our brain's potential. List some of the ways to improve the working of your brain. Then decide which ones you are going to pursue.
2. We know that the brain is fairly sensitive to coffee, sleep, drugs, and food. What are the implications of this sensitivity for our behavior?
3. We have seen that old people who stay active develop fewer cases of some brain diseases. Do you know any older people who are very mentally alert? What are their mental activities, such as reading, hobbies, talking with people, and so forth?
4. Do you know any young people who do not show much intellectual interest or activity? Do you find any areas in your own life in which you are intellectually lazy? Reading a challenging book is food for the mind. What else could you do to give your mind regular workouts?
5. In the Shakespeare quotation on page 61, what do you think is the "enemy" that can steal away our brains?
6. Using your own experience or the experience of others you know, identify instances in which the drugs mentioned in this chapter clouded thinking and judgment. What were the consequences of the person's reduced ability to think critically?
7. How is it that a physical brain can give rise to a mental world that has properties that the physical world does not? Are there other situations in which physical matter generates something that has non-physical properties?