1

BRAIN AND SLEEP

"All my life I have focused on being healthy, but I wanted to learn more about slowing the aging process. Your regimen is effective because I continually receive statements like: 'You look fantastic! What do you do to keep looking so young?' I know for a fact that people think I am considerably younger than my chronological age."

SANDY (55), NASHVILLE, TENNESSEE

Part I of this book describes the Problem—the fact that we are genetically programmed to age, to enjoy optimal health for a relatively short period of time, and then are forced to spend much of the rest of our lives dealing with the effects of *aging*, a process that has as its sole purpose the destruction of our health and our ultimate demise. Before we begin our discussion of the various processes associated with aging, it is important to realize that *growing older* (and wiser!) is not the same thing as aging. Everyone grows older all the time, but we aren't necessarily aging as we do so since, by definition, the aging process is one of deterioration.

You grew older today, but did you age as well? If you drank a few cups of green tea, had five servings of fruits and vegetables, exercised for at least 30 minutes at your target heart rate, took nutritional supplements optimized for your age and health situation, spent quality time with close friends and loved ones, consumed a glass of red wine, had a romantic (and sensual!) time with your spouse or significant other, and got 8 hours of quality sleep, then you probably aged very little if at all. If you were a coach potato, ate doughnuts for breakfast, skipped lunch, consumed an excessive amount of coffee, smoked cigarettes, and got into stressful arguments with friends, co-workers,

and loved ones, then you probably aged a lot. People can look old in their thirties or young in their sixties, and the lifestyle choices you make every hour make all the difference.

Multiple processes cause us to age. Some are simple, such as the depletion of a vital substance called phosphatidylcholine in our cell membranes (which you can reverse by supplementing with that substance as we discuss below). Some are complex, such as keeping your most important organ—your *brain*—healthy. In this chapter, we'll discuss optimal brain health along with sleep since sleep is so vital to brain function. Then we'll move down to the heart, the digestive tract, and the sexual organs and hormones. We'll complete our overview of how the body works with a discussion of various metabolic processes, including inflammation, methylation, and glycation, and finally look at genomics, the new field that is unlocking the secrets of our genes, which control and regulate all bodily functions.

WE THINK, THEREFORE WE ARE

Your brain makes up only 2 percent of your weight yet receives 20 percent of the blood coming from the heart and uses 20 percent of your body's oxygen and glucose. It also represents 50 percent of your genetic complexity. In other words, half of your genes describe the design of your brain, with the other half describing the organization of the other 98 percent of your body. Moreover, your brain is the master puppeteer: It controls every beat of your heart, every blink of your eyes, the release of your hormones, not to mention all of your willful activities. It has long been regarded as the seat of consciousness, the true you. So it makes sense to consider what you can do to keep it healthy—and happy, too! As it turns out, there is a lot you can do. The ideas in this chapter can dramatically slow down brain aging and help you avoid the often catastrophic downsides of brain dysfunction.

Intelligence is arguably the most important phenomenon in the world because intelligence allows us to understand and shape our environments. The best example we have of an intelligent entity is the human brain itself. And the secret of its design is not hidden from us. Although there's a skull

around it, we can see inside a living brain with increasingly precise scanning technologies. This is a wonderful example of Ray's law of accelerating returns: The spatial resolution of brain scanning is doubling every year, and the amount of data we are gathering on the brain is also doubling every year.

We now know the human brain is composed of about 100 billion neurons plus a trillion *glial* support cells. It was originally thought that the glial cells just provided physical support for the neurons, but recent studies have demonstrated that they play a role in influencing the synapses, which are the connections between neurons. We have about 100 trillion such connections, and that is indeed where most of the action takes place. So there is a lot of complexity.

We are gathering an exponentially expanding mountain of data on the brain, but can we understand it? A controversy going back thousands of years to the days of Plato is whether we are intelligent enough to understand our own intelligence. Computer scientist Douglas Hofstadter wrote that "it could be simply an accident of fate that our brains are too weak to understand themselves." Since Hofstadter wrote that line in 1979, we have shown that this is not the case. As we gather enough data on specific brain regions, we have been able to model these areas in precise, mathematical terms and actually simulate them on computers. For example, computer scientist Lloyd Watts and his colleagues have created a computer simulation of a dozen regions of the auditory cortex, the regions of the brain responsible for processing sound from the ears. Applying sophisticated psychoacoustic tests to Watts's simulation produces results very similar to applying these tests to human auditory perception. At MIT, there is a similar model and simulation of the visual cortex, which processes visual information.

At the University of Texas, there is a simulation of the cerebellum, an important region that makes up more than half of the brain's neurons and is responsible for skill formation, for example, catching a fly ball. We have always wondered how a 10-year-old accomplishes this feat. All she has to do is solve a dozen simultaneous differential equations in a few seconds, but most 10-year-olds have not yet taken calculus. We now understand how this works. Those equations are indeed solved by her cerebellum using a mathematical technique called basis functions. It takes place, of course,

without conscious awareness, and we do have to train the cerebellum to learn specific tasks, which is why practicing a skill is important. Again, a variety of tests on this computer simulation of the cerebellum provides results similar to human skill formation using our biological cerebellum. This illustrates the oft-stated insight that although the brain is capable of some remarkable accomplishments, we perform these feats without much understanding of how our brains actually carry out these missions.

An ambitious project is underway at IBM to simulate the cerebral cortex, arguably the most important region of the brain and the one responsible for our abstract reasoning. As of the writing of this book, this simulation has successfully undergone its first set of tests.

As we continue the accelerating progress toward "reverse-engineering," understanding the methods of how the brain works, we'll gain far greater insight into our own human nature, which has been the goal of the arts and science since we first wrote symbols on stone tablets over 5,000 years ago. The results of this grand engineering project, which now includes over 50,000 scientists and engineers, will also provide us with methods for ever more intelligent computer software. But the benefit most relevant to this book is that we will gain far more powerful ways of fixing what goes wrong in our brains.

And there is a lot that does go wrong. As we pointed out before, evolution focused on our formative years and enough of our early adulthood to allow us to raise our children so that they became self-sufficient. As a result, keeping our brains healthy much past our twenties was not a trait selected by natural selection when our brains evolved. Our brains are subject to either sudden or gradual decline with age, to self-destructive addictive behaviors, to depression and anxiety disorders, and to many other limitations, not to mention potentially catastrophic lapses of judgment.

YOU CREATE YOUR BRAIN

Perhaps the most important insight relevant to brain health that has come from recent advances in information technology is the *plasticity* of the brain. Since the mid-19th century, it was thought that brain regions were hardwired

for specific tasks and that neurons could not be replaced. In 1857, French neurosurgeon Paul Broca related specific cognitive deficits to particular regions of the brain affected by injury or surgery. For more than a century, it was believed that unlike other areas of the body that are capable of repairing themselves, the brain could not replace its neurons and connections that had been lost or damaged and that we are continually and irretrievably losing brain matter.

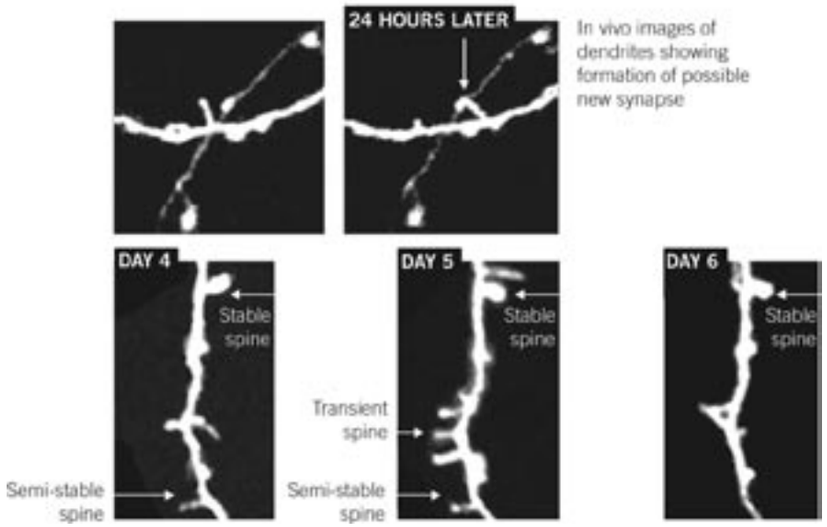
From recent brain imaging research, we now know the brain possesses *plasticity*, meaning it is perhaps the most dynamic and self-organizing organ of the body. Although there is some degree of specialization in the skills of different regions of the brain, stroke victims are often able to transfer skills from a damaged region to one that is undamaged. Moreover, we can see in recent brain scans how we actually grow new brain connections and even create new neurons from stem cells as a result of our thoughts.

In an experiment with monkeys at the University of California, brain scans obtained before and after the animals were trained to perform a specific task involving the nimbleness of one finger showed substantial growth in neural connections associated with controlling that finger. An experiment with humans who were taught how to play the violin showed substantial growth of connections associated with the fingers of the left hand responsible for controlling the notes. A brain scanning experiment at Rutgers and Stanford universities involved training dyslexic (reading-impaired) students how to distinguish between hard-to-resolve consonants such as "p" and "b." After the training, brain scans showed substantial growth and increased activity in the region of the brain responsible for this discrimination. Paula Tallal, one of the scientists who created this dyslexic training system, commented that "you create your brain from the input you get."

In the latest brain image studies, we can see real-time movies of individual interneuronal connections actually creating new synapses (connection points between neurons), so we can see our brain create our thoughts and in turn see our thoughts create our brain.

The true meaning of Descartes' famous dictum, "I think therefore I am," has been debated for centuries, but these findings provide a new interpretation: I do indeed create my mind from my own thoughts.

IN VIVO IMAGES OF NEURAL DENDRITES SHOWING SPINE AND SYNAPSE FORMATION



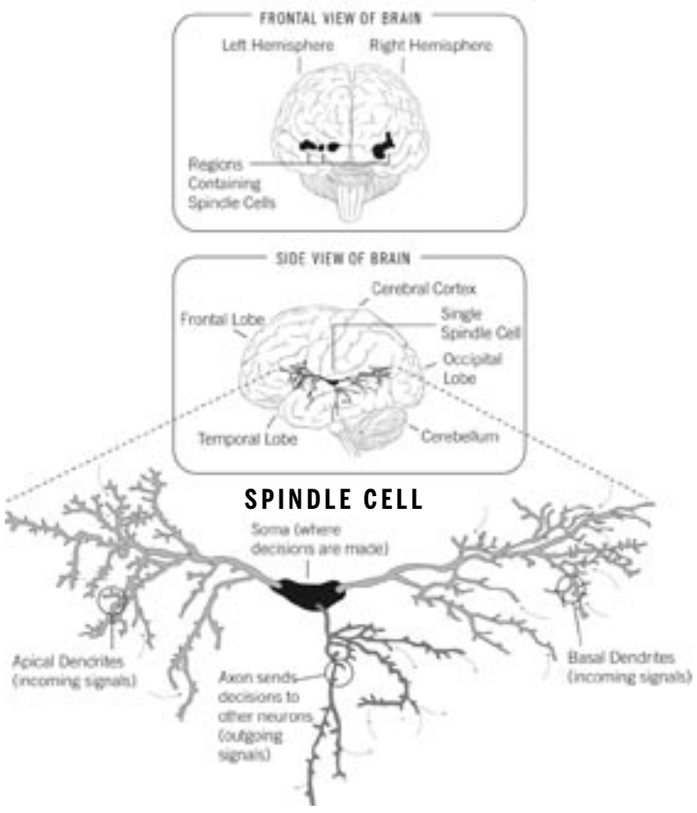
The lesson of these new insights is that our brain is entirely like any of our physical muscles: *Use it or lose it.* We all know what happens to your muscles if you are bedridden from illness or just living the couch potato life. The same thing happens to your brain. By failing to engage it in intellectually challenging activities, your brain will fail to grow new connections, and it will indeed become disorganized and ultimately dysfunctional. The converse is also true for both body and brain. If someone who has not been physically active for a sustained period starts a program of physical therapy and regular exercise, she can regain her muscle mass and tone within a matter of months. The same thing is true of your brain.

Many studies demonstrate that people who maintain their intellectual activities throughout life remain mentally sharp. A Canadian study called the Victoria Longitudinal Study has shown that older individuals who routinely engage in mentally challenging activities, including everyday activities such as reading, remain mentally alert, as compared with the substantial cognitive decline of those who do not engage in these activities.

Just as we have more than one muscle to keep fit, we have more than one

region of the brain that we need to exercise. To keep the cerebellum—the region of the brain that controls voluntary movement—healthy, you should engage in physical activities, particularly those that involve the development of skills such as sports.

The concept that certain brain activities occur in the left half of the brain and others on the right is only partially true. A recently discovered type of neuron called the spindle cell crosses from one side of the brain to the other and appears to be heavily involved in higher-level emotions. In recent brain scanning experiments using new types of scanners that can image individual neurons, these cells "light up" (become especially active) when test subjects are shown a picture of a loved one or hear their child crying. The spindle cells are unusual in that they can be very long, spanning the entire length of the



brain, and are deeply interconnected with other neurons. One spindle cell will typically have hundreds of thousands of connections to other cells. Unlike the highly organized cells of the cerebral cortex, the brain region responsible for rational thought, the spindle cells display unpredictable and fairly exotic structures and connection patterns.

They are connected to almost every other region, so they receive input from everything else going on in our brain. From these studies, it is apparent that the spindle cells are not doing rational problem solving, which is why we don't have rational control over our emotional responses.

Although each spindle cell is very complex, we don't have very many of them. Only about 80,000 of our 10 billion neurons are spindle cells. Only a few animal species have spindle cells at all. Gorillas have about 16,000, bonobos about 2,100, and chimpanzees about 1,800. Recently we have discovered that whales actually have more than humans. Interestingly, newborn humans don't have any spindle cells. They begin to appear at about 4 months and develop through 3 years of age, which exactly mirrors the ability of young children to deal with higher-level emotions and moral issues.

About 45,000 of the spindle cells are in the right hemisphere, and 35,000 are in the left. This small imbalance appears to account for the notion that the right brain is the emotional brain and the left brain is the more rational brain. Although the right brain does have more spindle cells, both halves of the brain are engaged in logical and emotional activities. Individuals with a rare disorder who use only half of their brain often appear to behave almost normally, engaging in both logical and emotional activities.

EXERCISING YOUR MIND

The concept that the right brain is responsible for creativity and emotion and the left brain is the center for rational and logical thought is more metaphor than reality. Nonetheless, in terms of exercising your brain, it is important to engage both your logical and your emotional faculties. To the extent that your job or educational activities do not engage your logical brain, find activities that require problem solving. There are myriad examples, ranging from board games such as chess to solving crossword or Sudoku puzzles. Keeping track of

your finances or planning a trip will engage your logical mind. Reading and writing certainly engage both aspects of your brain. Express your creative and artistic urges by studying a musical instrument. Learn to create art using any modality, including computer graphics. Take up a hobby. Take an adult education course. Travel to new places. Engage in conversations with interesting and thoughtful people. Most important, emphasize interpersonal relationships. Strong connections to others deeply engage both types of mental activities and satisfy a basic human need, as discussed in Chapter 9.

So, here's a useful suggestion on what you can think about to keep your brain healthy: Contemplate how to keep your brain—and body—healthy. You can start by adapting the suggestions in this book into your personal plan!

Terry2023: We now have the capability of overcoming nerve damage, such as spinal cord injuries, using stem cells. Formerly disabled persons are now walking again.

Reader: That research must have already started today if it's working in humans in 2023.

Ray2023: It was not only started, but in your day, MIT scientist Robert Langer was already growing artificial nerves from stem cells in paraplegic mice, enabling these mice to walk again.

Reader: Completely normally?

Terry2023: It was not a completely normal gait but was pretty good. Any physically disabled human would be delighted to walk as well as these once-paraplegic mice could.

ADDICTION

One of the downsides of our brains that we alluded to above is its tendency to addictive behaviors. With our recent ability to model and simulate the information processes underlying our biology and mental activity, we are rapidly gaining an increasingly intricate understanding of the biochemical pathways to addiction. For example, dopamine is the neurotransmitter of pleasure. Dopamine is released when we achieve an accomplishment, win a contest, connect with someone in a loving and nurturing relationship, create a new idea, or even just appreciate someone else's new idea. When people have difficulty achieving regular releases of dopamine through these kinds of socially accepted activities, they will often seek a shortcut.

Gambling provides one such shortcut. Dopamine release is enhanced when a positive outcome is a surprise, so the thrill of winning at gambling can be especially effective in releasing dopamine. This reminds us of an episode of the old series *The Twilight Zone* in which a gambler dies and goes to heaven. Upon his arrival, he is delighted to find himself surrounded by gorgeous women, and, to his further delight, he discovers that he wins every turn of the roulette wheel. But his delight quickly wears thin, and he ultimately finds his persistent winning to be profoundly troubling. He tells the angel in charge that he would really rather go to the "other place." "But this is the other place," the angel replies. So the allure of gambling is dependent on its lack of predictability. And we all know that the odds in gambling are stacked against you; therefore, becoming dependent on this form of dopamine release can eventually become ruinous.

We see a similar self-defeating cycle in the dependency fostered by the initial pleasure generated from addictive drugs. Though addiction remains a troubling scourge, rapid progress is being made in understanding the genetic basis of such behavior. For example, mutations of the dopamine-receptor D2 gene have been associated with addictive abuse of substances, including illegal drugs such as cocaine and heroin, as well as smoking and abuse of food. These genetic mutations can produce unusually intense feelings of pleasure from early experiences with these addictive substances, but in a well-known pattern, the ability of these substances to continue to provide such pleasure becomes depleted. Other genetic mutations can also result in a generally diminished ability for dopamine release from everyday gratifications, leading people with these mutations to turn to other substances and activities to raise dopamine levels to normal.

Aside from the moral, ethical, and legal problems that may result from addictive behavior, the release of pleasurable neurotransmitters such as dopamine from substance abuse or another addictive behavior gradually depletes the brain's supply of dopamine and other pleasure neurotransmitters. This leads to an increasingly desperate dependence on the addictive substance or behavior. Over time, this leads to a catastrophic change in brain chemistry that often requires professional help to resolve.

Studies have shown that moderate use of alcohol is associated with increased longevity, and there is nothing wrong with occasional gambling as

a recreational activity. The majority of the population is not genetically susceptible to addiction to either alcohol or gambling, but a substantial portion is; it's important to determine whether you have this susceptibility. If you find that you have this genetic tendency, you'll need to steer clear of activities that may cause you to fall into this pernicious form of mental quicksand.

A new generation of drugs in development promises to change the biochemistry of an addicted person closer to where it was before the addiction occurred. These drugs do not necessarily change the original susceptibility, so they appear to work best in conjunction with traditional drug treatment programs. Unfortunately, the rate of recidivism for addictions to drugs, gambling, and other addictive behaviors is very high, even with counseling programs. It is well known that drug addicts are considered never to be "cured" but to consider themselves "recovering addicts" indefinitely. The hope is that this new generation of drugs, which specifically targets the insidious neurotransmitter and hormonal cycles that reinforce addictive behavior, can be helpful in reducing recidivism.

HEALTHY LIFESTYLE, HEALTHY BRAIN

As we've discussed, in many ways you are what you think. But the old dictum that you are what you eat is also true. In addition to keeping your brain challenged, our dietary recommendations as outlined in Chapters 11 and 13 constitute your first line of defense for maintaining a healthy brain. Your brain is 60 percent fat, so consuming healthy fats is especially important for brain health. Both EPA and DHA, the principal components of the omega-3 fats found in fish, are important constituents in brain tissue.

Inflammation (overactivation of the immune system) is a major accelerator of brain aging, so our dietary recommendations aimed at reducing inflammation (such as avoiding high-glycemic-index carbohydrates such as sugary foods and starches) are also important for brain health.

The following brain nutrients have been shown in double-blind placebo-controlled studies to have significant benefits for brain health, as cited in leading medical journals such as *Nutrition*:

Vinpocetine, a natural supplement derived from the periwinkle plant, increases bloodflow to the brain as well as increases the production of adenosine triphosphate (ATP), the brain's energy source. It has been shown to enhance memory for people with normal memory as well as those with memory impairment.

Phosphatidylserine is a natural constituent of the cell membrane but is found in especially high concentrations in the brain. Supplementing with phosphatidylserine slows down memory loss and has been shown to reverse memory loss in some patients with age-related memory decline. It also lowers levels of cortisol, a principal hormone of aging.

Acetyl-L-carnitine is a natural substance that strengthens the mitochondria, the energy sources inside the cell. It also protects the brain from aging by slowing down inflammation of brain tissues.

Ginkgo biloba has been a staple of Chinese medicine for thousands of years. It increases bloodflow to the brain, and numerous studies show that it reduces short-term memory loss in the elderly. Ginkgo biloba is a prescription drug in Europe, where it is prescribed more than any other pharmaceutical substance for memory loss.

EPA and DHA are the principal components of omega-3 fats and are both found in high concentrations in brain tissue. Both help keep brain cell membranes flexible. As mentioned, the brain is 60 percent fat; when EPA and DHA levels are inadequate, the brain will substitute less desirable fats, such as omega-6 fats and even the dangerous trans fatty acids. When this happens, cell membranes lose their flexibility, and the transmission of signals between neurons becomes impaired. Many studies have shown improved mood and relief from symptoms such as depression and anxiety from supplementation with EPA/DHA.

Phosphatidylcholine (PC), as discussed in Chapter 2, is a key constituent of the cell membrane of all of our cells, including brain cells. Studies have shown that supplementing with PC can help with memory and learning in humans without mental impairment.

S-adenosyl-methionine (SAMe) is a natural derivative of an amino acid normally produced by the body, and it plays a role in methylation (see Chapter 5). Levels of SAMe in the body often become depleted by middle age.

Multiple clinical trials have shown that SAMe provides substantial benefit for patients with depression. This effect occurs relatively quickly, unlike the requirement to build up levels in the bloodstream that accompanies some prescription drugs for depression. It is, therefore, an effective, natural, and quick-acting treatment for mild depression. Human trials have also shown benefits for strengthening the liver and for relief from osteoarthritis.

NATURAL SUPPLEMENTS FOR BRAIN HEALTH

SUPPLEMENT	RECOMMENDED DOSAGE
Vinpocetine	*10 milligrams twice a day*
Phosphatidylserine	*100 milligrams twice a day for 1 month, decreasing to 100 milligrams daily thereafter*
Acetyl-L-carnitine	*500 to 1,000 milligrams twice a day*
Ginkgo biloba	*80 to 120 milligrams twice a day*
EPA/DHA	*1,000 to 3,000 milligrams EPA daily* *700 to 2,000 milligrams DHA daily*
Phosphatidylcholine	*900 milligrams two to four times a day*
SAMe	*200 to 400 milligrams twice a day*

RayandTerry2034: Had we written this book today, we could have written it in a few days because of the nanobots in our brains.

Reader: Run that by me again.

Terry2034: We have many millions of blood cell–size robots in our bloodstreams. They keep us healthy from inside by destroying pathogens, repairing cells, removing toxins and debris, and correcting DNA errors. They also travel to our brains through the capillaries, basically providing computerized neural implants noninvasively, that is, without surgery. In our brains, they interact directly with our biological neurons to extend our memories and access to knowledge.

Reader: Okay, now that sounds awfully futuristic.

Ray2034: Yes, well, we are speaking to you from 2034.

Reader: But that's only about a quarter century from now.

Ray2034: Because of the doubling of the power of information technology in less than a year, computer technology today is millions of times more capable than it was 20

years ago, and it was pretty impressive then. It has also become more than 10,000 times smaller.

Reader: But we can't do anything like that today, so even with a millionfold increase in capability . . .

Ray2034: Actually, that's not the case. Back in your day, you could also have a computer put into your brain.

Reader: I can?

Terry2034: Well, if you're a patient with Parkinson's disease, you can. It was not blood cell size 20 years ago; it was more like pea size. But it did replace a region of the brain destroyed by the disease and communicated with the neurons in neighboring regions, namely the ventral posterior nucleus and the subthalamic nucleus, just like the original biological brain region did. And it was also possible to download new software to the computer in the brain from outside the patient.

Reader: This was an experiment?

Terry2034: No, it was an FDA-approved therapy. And there were other neural implants being developed back then, including retinal implants, chips that enable a stroke patient to control his computer from his brain, an artificial hippocampus for boosting short-term memory, and many others. If you apply the approximately 30 million–fold increase in capability and over 100,000-fold shrinking in size that has occurred in the past quarter century, we now have much more capable devices that are the size of blood cells.

Reader: Still, it's hard to imagine building something the size of a blood cell that can perform a useful function.

Terry2034: Actually, there was a first generation of blood cell–size devices back in your day. One scientist cured type 1 diabetes in rats with a blood cell–size device. It was an excellent example of nanotechnology from the first decade of this century. Its 7-nanometer pores let insulin out in a controlled fashion and blocked antibodies. At MIT, they developed a blood cell–size device that could scout out cancer cells and destroy them. So, if you just apply the law of accelerating returns to what was feasible 25 years ago, then having millions of blood cell–size devices in our bloodstreams today in 2034 to augment our physical and mental capabilities should not be so surprising.

Reader: Okay, so what do these nanobots in your brain allow you to do?

Ray2034: For one thing, they provide a search engine directly from our brains. The nanobots listen in on our thoughts, and if they see we're getting stuck on something, they provide useful information to keep the creative process going.

Reader: I can buy that. The fact that I have access to all human knowledge with a few keystrokes using a device that fits in my shirt pocket is already pretty amazing.

Ray2034: We now have direct brain-to-brain communication since the nanobots are on the Internet.

Reader: I guess no one wonders too much about telepathy in 2034?

Ray2034: That's true. The nanobots can also put us into full-immersion virtual reality environments.

Reader: How does that work?

Ray2034: If we want to go into a virtual reality environment, the nanobots shut down the signals coming from our real senses and replace them with the signals that our brains would be receiving if we were actually in the virtual environment. Then to our brain, it feels like we are in that virtual environment.

Terry2034: If you want to move your arm, it is your virtual arm that moves, so you can be an actor in these virtual reality environments. The environments are as imaginative as games were in your day—some are recreations of earthly environments like a beautiful beach, and some are fantastic environments that defy the laws of physics. You can go to these virtual environments yourself or meet with others. You can interact using all of the senses.

Reader: And you look just the way you do in real reality?

Ray2034: That's an option, but you can also change who you are. You don't have to be the same person all the time.

Reader: So you just forget about real reality?

Ray2034: At times. But most of the time, we live in augmented reality, basically a blend of real and virtual realities. Little avatars pop up explaining what's going on in the real world. It's hard to know where real reality stops and virtual reality starts; it's all kind of blended together.

Reader: Anything else?

Terry2034: The nanobots extend all of our mental capabilities, our memories, our ability to think logically, to perceive patterns. They're true brain extenders.

Reader: Well, I have a brain extender today in 2009. As I said, this computer in my pocket is already extending my mental reach.

Ray2034: Exactly. Extending our reach through our tools is really a very old idea.

TO SLEEP, PERCHANCE TO DREAM

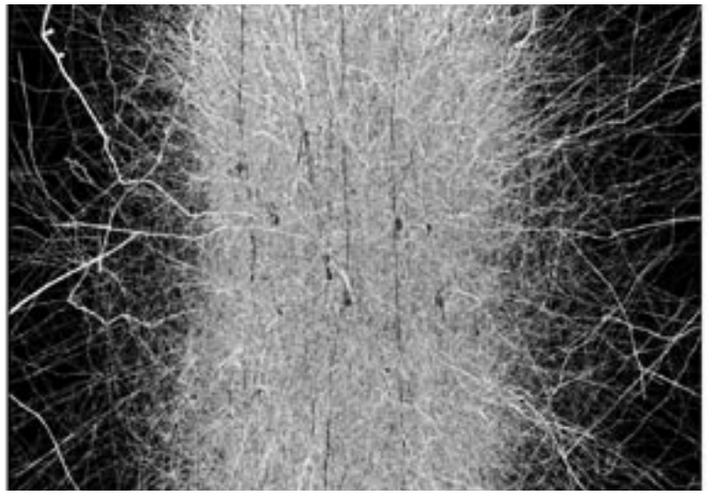
Shakespeare's lines illuminated sleep and dreams as among life's precious pleasures. We all value a good night's rest, and yet research shows that one person in three is chronically sleep deprived. People often try to solve the problem by consuming a lot of caffeine in the morning, but this habit has cultivated a population of nervous—*and still tired*—individuals.

Sleep has also been shown to have many other important functions for health. The brain consumes 20 percent of the body's supply of glucose, and sleep improves glucose uptake into the brain. A baby's brain can use as much as 50 percent of the total glucose supply, which may help explain why babies need so much sleep. *Leptin* is a hormone that decreases appetite, and leptin levels rise during sleep. Many people today don't get enough sleep, which may help explain the dramatic rise in the number of people with weight problems. Sleep improves memory and the ability to learn and retain new material. Lack of sleep adversely affects mood and decreases energy. We feel that getting adequate sleep is just as important as diet and exercise in everyone's wellness program.

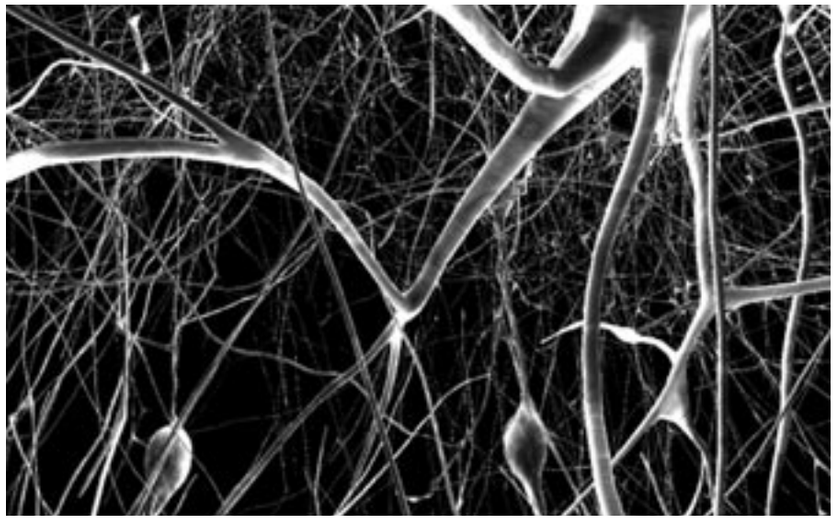
The most important phase of sleep, called REM (rapid eye movement), makes up about a quarter of our time spent sleeping. This is the phase during which you do the most dreaming and are most likely to remember your dreams. Your eyes move rapidly as if you were engaged in a drama from your waking life, although the body from the neck down is largely paralyzed.

Recent advances in brain scanning technology have begun to reveal why sleep is so important. We can actually see in brain scans of a living brain how our brain reorganizes itself during dreaming and processes the information that streamed into our brains during the day. In the journal *Science*, scientists reported studies of the brain during dreaming, especially during REM sleep, using a brain scanning technology called positron emission tomography (PET). They found that many regions of the brain are just as active during dreaming as when awake, some actually substantially more so. The brain continues to process visual images, though obviously not from the eyes; and the regions of the brain that process new visual information, including regions of the frontal lobe that combine processed information from the eyes

with other sensory information, are quiet. But the regions of the brain involved in creating new memories and making sense of our emotions are even more active than when we are awake. The amygdala, a region responsible for intense emotions such as fear, as well as other regions responsible for



Working computer simulation of a slice of the cerebral cortex.



High Resolution Brain Scan

consolidating emotional memories, is especially active during REM sleep. Psychiatrist J. Allan Hobson of Harvard Medical School, a researcher on the PET brain imaging study, commented that "the PET results are consistent with Freud's idea that dreams have meaning."

Research at Harvard Medical School has demonstrated that sleep helps us absorb new information and process our experiences in a procedure called memory consolidation. In studies, people who slept adequately after studying a new task scored significantly higher on tests than people who did not sleep well. With the most recent brain scanning technology, we can now actually see the brain make new connections as it creates new memories and new insights by processing information gathered through the day.

An agreement on the exact role of dreaming will require further progress on reverse-engineering the brain in general, but there is a growing consensus that dreaming is not just a random process of neural firing and that it is vital for our mental and even our physical health.

Each of us will experience occasional periods of poor sleep resulting from a wide range of distractions, such as gastrointestinal upset and daytime worries, but the serious health concern is chronic sleep deprivation. Harvard Medical School reports a wide range of negative effects from a consistent failure to get a good night's sleep. It can cause weight gain by affecting leptin levels that control appetite as well as our ability to process carbohydrates efficiently. Sleep deprivation has been linked to hypertension and increased levels of stress hormones, which heighten the risk of heart disease. It can suppress the immune system, which can increase the risk of cancer and other diseases. Not sleeping can make you accident prone. And not sleeping adequately can wreck your mood and ability to concentrate.

In our own experience, we have found that if we get a good night's sleep (which is most of the time), we have a positive attitude toward life and have the energy and optimism to deal with the challenges that each day brings. Conversely, if we've slept poorly, even small problems can stick and become upsetting.

Our first recommendation with regard to sleep is to recognize its importance and to give it a high priority. Pulling an all-nighter to make a deadline is invariably self-defeating. Following the recommendations in this book will put you in close touch with your body and your needs so you will be able to identify just how much sleep you need. Although sleep requirements do vary from person to person, most people need at least 7 to 8 hours per night.

Here's our seven-point program for getting a good night's sleep every night:

1. Eat right. By following the nutrition recommendations in this book, you'll feel better overall, your gastrointestinal system will be happier, and you'll sleep better.
2. Remember that exercise promotes a natural cycle of sleep. If you have difficulty sleeping, increase your aerobic exercise, although you shouldn't exercise right before retiring for the night. Aerobic exercise releases endorphins, which are natural chemicals that reduce stress.
3. Follow our guidelines for reducing stress, as outlined in Chapter 9.
4. Practice good sleep hygiene before retiring. This means slowing down and engaging in relaxing activities such as reading before going to bed. Working on a stressful project or listening to stimulating music is not the best way to wind down. Having a regular routine at the end of the day is conducive to sleep.
5. If you have difficulty sleeping, cut down on caffeine or avoid it altogether. Don't consume caffeine in the afternoon or evening.
6. Assess whether you suffer from sleep apnea, a common condition in which the mouth opens widely during sleep, causing a temporary blockage of air and decline in available oxygen. This is a very common reason that people do not sleep well. The periods of apnea (literally, "no air") during the night increase risk of both high blood pressure and heart disease. A person undergoing a sleep apnea event may appear to be gagging, although many apnea events produce no visible symptoms. People with moderate to severe sleep apnea may have dozens to hundreds of such events each night. This condition, found in many patients who snore a lot, can be diagnosed in a sleep clinic.

There are also home tests that use a finger-mounted electronic probe to monitor blood-oxygen levels. Excess body weight contributes to sleep apnea, so achieving optimal weight is one approach to solving the problem. One popular treatment is CPAP (continuous positive airway pressure), in which the patient wears a mask connected to a device that maintains positive airway pressure, reducing sleep apnea events. This cumbersome device is indeed intrusive, but some people who suffer from severe sleep apnea find that the inconvenience is worth it to be able to sleep well. Another approach is a prescription dental appliance that is form-fitted to your teeth. Worn at night, this appliance forces your lower jaw forward and thereby prevents sleep apnea events. We recommend you look into this dental appliance before considering CPAP, as it is much less intrusive and for many people works just as well. For mild apnea, try not to sleep on your back because apnea is much more likely in this position. If necessary, sew a tennis ball to the back of your pajama top to keep you from sleeping on your back.

7. Consider the following natural supplements, which are helpful for ensuring a good night's sleep (the authors take some of these):
   - L-theanine is a substance found in tea and promotes relaxation.
   - GABA is a neurotransmitter and a natural, mild tranquilizer. We recommend 500 to 1,000 milligrams before retiring.
   - Melatonin is a natural hormone that controls the body's sleep clock. Normally, the body's level of melatonin dramatically increases when it is time to go to sleep. This in turn triggers a cascade of other hormonal changes to prepare the body for sleep. Melatonin levels decline with age, which is one reason people have more difficulty falling and staying asleep as they get older. You should take melatonin only when it is time to start your night's sleep. Do not take it in the middle of the night if you wake up because that will confuse your body's sleep clock. If you have trouble falling asleep, we recommend the sublingual form, which will go directly into the bloodstream. Standard oral preparations or timed-release preparations are better if you have trouble staying asleep. A wide range of doses, from 0.2 to 10 milligrams, are usually effective. The sublingual form is also available in doses of 2.5 to 3 milligrams. Usually a 1-milligram sublingual dose is sufficient, and many people find that larger doses leave them groggy the next day. Melatonin is also useful for resetting your sleep clock when you change time zones. In this case, take melatonin when it is time to go to sleep in the new time zone.

Terry2023: Sleep scientists have developed methods so that people don't need to sleep much at all.

Reader: But I love to sleep, and dreaming is fun—how else can you fly through the clouds or dance with the elephants?

Ray2023: We now have virtual reality technologies that allow us to do these things while we're awake, but most people still get normal sleep most of the time. A good night's sleep and dreams can certainly be enjoyable and comforting.

Terry2034: Sleeping is optional now. These days, most people still choose to get normal sleep, but we now have devices and medications that produce many of the same benefits of sleep without your needing to lie down. But, like most people, I still find that I feel better with a good night's sleep than with these new versions.

Ray: I agree. I find I'm much more productive if I've slept well.

Reader: I know, but every once in a while it would be great to not have to spend 7 or 8 hours in bed—like when I have an important deadline.

Terry: Ray, why don't you tell the readers the technique you've developed for solving problems while you sleep—your *lucid dreaming* technique?

Ray: I've developed my problem-solving method over several decades and have learned the subtle means by which it is likely to work better.

I start out by assigning myself a problem when I get into bed. This can be any kind of problem. It could be a math problem, an issue with one of my inventions, a business strategy question, or even an interpersonal problem.

I'll think about the problem for a few minutes, but I try not to solve it. That would just cut off the creative process to come. I do try to think about it. What do I know about

this? What form could a solution take? And then I go to sleep. Doing this primes my subconscious mind to work on the problem.

Terry: Sigmund Freud pointed out that when we dream, many of the censors in our brain are relaxed, so that we might dream about things that are socially, culturally, or even sexually taboo. We can dream about weird things that we wouldn't allow ourselves to think about during the day. That's at least one reason why dreams are strange.

Ray: There are also professional blinders that prevent people from thinking creatively, many of which come from our professional training, mental blocks such as "you can't solve a signal processing problem that way" or "linguistics is not supposed to use those rules." These mental assumptions are also relaxed in our dream state, so I'll dream about new ways of solving problems without being burdened by these daytime constraints.

Terry: There's another part of our brain not working when we dream, our rational faculties to evaluate whether an idea is reasonable. So that's another reason that weird or fantastic things happen in our dreams. When the elephant walks through the wall, we aren't shocked as to how the elephant could do this. We just say to our dream selves, "Okay, an elephant walked through the wall, no big deal." Indeed, if I wake up in the middle of the night, I often find that I've been dreaming in strange and oblique ways about the problem that I assigned myself.

Ray: The next step occurs in the morning in the halfway state between dreaming and being awake, which is often called *lucid dreaming*. In this state, I still have the feelings and imagery from my dreams, but now I do have my rational faculties. I realize, for example, that I am in a bed. And I could formulate the rational thought that I have a lot to do, so I had better get out of bed. But that would be a mistake. Whenever I can, I will stay in bed and continue in this lucid dream state because that is key to this creative problem-solving method. By the way, this doesn't work if the alarm rings.

Reader: Sounds like the best of both worlds.

Ray: Exactly. I still have access to the dream thoughts about the problem I assigned myself the night before. But now I'm sufficiently conscious and rational to evaluate the new creative ideas that came to me during the night. I can determine which ones make sense. After perhaps 20 minutes of this, I invariably will have keen new insights into the problem.

I've come up with inventions this way (and spent the rest of the day writing a patent application), figured out how to organize material for a book such as this, and come up with useful ideas for a diverse set of problems. If I have a key decision to make, I

will always go through this process, after which I am likely to have real confidence in my decision.

The key to the process is to let your mind go, to be nonjudgmental, and not to worry about how well the method is working. It is the opposite of a mental discipline. Think about the problem, but then let ideas wash over you as you fall asleep. Then in the morning, let your mind go again as you review the strange ideas that your dreams generated. I have found this to be an invaluable method for harnessing the natural creativity of my dreams.

Reader: Well, for the workaholics among us, we can now work in our dreams. Not sure my spouse is going to appreciate this.

Ray: Actually, you can think of it as getting your dreams to do your work for you.

THE POWER OF IDEAS

When Ray was 7 years old, he started reading the Tom Swift Jr. series of books. The plots were all very similar: Tom and his friends would get into a terrible jam (often with the fate of the human race hanging in the balance). Tom would retreat to his basement lab and would come up with an idea—usually an invention—that saved the day. These books were one of the inspirations that led Ray to become an inventor. Both Ray and Terry are committed to the basic idea articulated in this children's series: No matter what difficulties we face, there exists an idea that can overcome the problem. So when you confront life's challenges, don't despair. Retreat to your "basement lab" knowing that the solution exists and you can find it and implement it. Both of us have in fact done this by overcoming the health challenges in our lives, the most recent of which has been "middle age" and the attendant challenges that come with it.

Often the idea that saves the day is a set of ideas, none of which by itself would be sufficient. We can reduce our risk of heart disease by as much as 95 percent, but this is not achieved by a single supplement or a single dietary rule. By aggressively reducing each and every risk factor, you can almost eliminate the risk of the number one killer in the developed world today. You can find these ideas in Chapter 2.

Here is a suggestion for an idea that you can adopt today that will change your life: You alone are responsible for your health—not your doctor, not your relatives, not your friends. You are not only the pilot, you're the only one on the plane. The ideas you need to get started on the right path are in this book. Once you're on the road to slowing down aging and dramatically reducing your risk of disease, you'll find that you will discover new ideas on a regular basis as our knowledge of how biology works continues to grow exponentially.

We are the only species that uses its brains to extend its horizons. We'll eventually have powerful new technologies to improve our brains in dramatic ways, but you can apply your own mental powers to start enhancing your life today.

2

HOW TO KEEP YOUR HEART BEATING . . .

until we come up with better ways to move your blood along!

"I feel better today at 50 than I did 10 years ago at 40. Your diet, supplements, and advice are helping me feel younger and more confident as the days go by. I have restored my cholesterol levels to normal after having them extremely high."

OSVALDO (50), SPAIN

Your heart is a seemingly tireless organ that has beat about a billion times by the time you're 30 years old. When healthy, its rhythm is more like a delicate dance than just a repetitive mechanical pump. It responds, of course, to our physical need for greater bloodflow when we exert ourselves, but its patterns are also affected by our moods and emotions, hence its reputation as the organ of love and affection.

As we discussed in the Introduction, our bodies evolved in an era when it was not in the interest of our species for people to live much past their twenties. In addition, our modern diets, which are high in saturated and other unhealthy fats, sugars, and starches, and our often sedentary lifestyles exacerbate the processes that lead to heart disease. Both of the authors have intensely studied the process of heart disease—and how to thwart it—for most of our lives. Ray was 15 when his father had his first heart attack at only 51; his father then died of heart disease at the age of 58. Ray's paternal