Can We Change?

Challenging the Dogma of the Hardwired Brain

The northern Indian district of Dharamsala is composed of two towns, lower Dharamsala and upper. The mist-veiled peaks of the Dhauladhar ("white ridge") range hug the towns like the bolster on a giant's bed, while the Kangra Valley, described by a British colonial official as "a picture of rural loveliness and repose," stretches into the distance. Upper Dharamsala is also known as McLeod Ganj. Founded as a hill station in the nineteenth century during the days of British colonial rule, the bustling hamlet (named after Britain's lieutenant governor of Punjab at the time, David McLeod) is built on a ridge, where hiking the steep dirt path from one guesthouse to another requires the sure-footedness of a goat and astute enough planning that you don't make the ankle-turning trek after dark and risk tumbling into a ravine.

Cows amble through intersections where street peddlers squat behind cloths piled with vegetables and grains, and taxis play a game of chicken with oncoming traffic, seeing who will lose his manhood first by edging his car out of the single lane of the town's only real thoroughfare. The road curves past beggars and holy men who wear little but a loincloth and look as if they have not eaten since last week, yet whose many woes are neatly listed on a computer printout that they hopefully thrust at any passerby

who slows even half a pace. Barefoot children dart out of nowhere at the sight of a Westerner and plead, "Please, madam, hungry baby, hungry baby," pointing vaguely toward the open-air stalls that line the road.

From the flagstoned terrace of Chonor House, one of the guesthouses, all of Dharamsala spreads out before you. As soon as the sun is up, the maroon-robed monks are scurrying to prayers and the holy men crouched in back alleys are chanting *om mani padme hum* ("hail to jewel in the lotus"). Prayer scarves fluttering from boughs carry the Tibetan words *May all sentient beings be happy and free from suffering.* The prayers are supposed to be carried by the wind, and when you see them, you think, Wherever the wind blows, may those they touch find freedom from their pain.

Although lower Dharamsala is inhabited mostly by Indians, residents of McLeod Ganj are almost all Tibetan (with a sprinkling of Western expatriates and spiritual tourists), refugees who followed Tenzin Gyatso, the fourteenth Dalai Lama, into exile. Many of those remaining in Tibet, unable to flee themselves, have their toddlers and even infants smuggled across the border to Dharamsala, where they are cared for and educated at the Tibetan Children's Village ten minutes above the town. For the parents, the price of ensuring that their children are educated in Tibetan culture and history, thus keeping their nation's traditions and identity from being erased by the Chinese occupation, is never seeing their sons and daughters again.

McLeod Ganj has been the Dalai Lama's home in exile and the headquarters of the Tibetan government in exile since 1959, when he escaped ahead of Chinese Communist troops, which had invaded Tibet eight years earlier. His compound, just off the main intersection where buses turn around and taxis wait for fares, is protected around the clock by Indian troops toting machine guns. The entrance is a tiny hut whose physical presence is as humble as the guards are thorough. From its anteroom, large enough for only a small sofa, dog-eared publications in a wooden rack, and a small coffee table, you pass through a door into the security room, where you place everything you want to bring in (bags, notebooks, cameras, tape recorders) on the X-ray belt before entering a closet-size booth, curtained at both ends, for the requisite pat-down by Tibetan guards.

Once cleared, you amble up an inclined asphalt path that winds past more Indian security guards draped with submachine guns and lounging in

the shade. The sprawling grounds are forested with pines and rhododendrons; ceramic pots spilling purple bougainvillea and saffron marigolds surround the widely spaced buildings. The first structure to your right is a one-story building that houses the Dalai Lama's audience chamber, also guarded by an Indian soldier with an automatic weapon. Just beyond is the Tibetan library and archives, and farther up the hill, the Dalai Lama's two-story private compound, where he sleeps, meditates, and takes most of his meals. The large structure to the left is the old palace where the Dalai Lama lived before his current residence was built. Mostly used for ordinations, for the next five days its large main room will be the setting for an extraordinary meeting. Brought together by the Mind and Life Institute in October 2004, leading scholars from both the Buddhist and the Western scientific traditions will grapple with a question that has consumed philosophers and scientists for centuries: does the brain have the ability to change, and what is the power of the mind to change it?

Hardwired Dogma

Just a few years before, neuroscientists would not even have been part of this conversation, for textbooks, science courses, and cutting-edge research papers all hewed to the same line, as they had for almost as long as there had been a science of the brain.

No less a personage than William James, the father of experimental psychology in the United States, first introduced the word *plasticity* to the science of the brain, positing in 1890 that "organic matter, especially nervous tissue, seems endowed with a very extraordinary degree of plasticity." By that, he meant "a structure weak enough to yield to an influence." But James was "only" a psychologist, not a neurologist (there was no such thing as a neuroscientist a century ago), and his speculation went nowhere. Much more influential was the view expressed succinctly in 1913 by Santiago Ramón y Cajal, the great Spanish neuroanatomist who had won the Nobel Prize in Physiology or Medicine seven years earlier. Near the conclusion of his treatise on the nervous system, he declared, "In the adult centers the nerve paths are something fixed, ended and immutable." His gloomy assessment that the circuits of the living brain are unchanging, its

structures and organization almost as static and stationary as a deathly white cadaver brain floating in a vat of formaldehyde, remained the prevailing dogma in neuroscience for almost a century. The textbook wisdom held that the adult brain is hardwired, fixed in form and function, so that by the time we reach adulthood, we are pretty much stuck with what we have.

Conventional wisdom in neuroscience held that the adult mammalian brain is fixed in two respects: no new neurons are born in it, and the functions of the structures that make it up are immutable, so that if genes and development dictate that *this* cluster of neurons will process signals from the eye, and *this* cluster will move the fingers of the right hand, then by god they'll do that and nothing else come hell or high water. There was good reason why all those extravagantly illustrated brain books show the function, size, and location of the brain's structures in permanent ink. As late as 1999, neurologists writing in the prestigious journal *Science* admitted, "We are still taught that the fully mature brain lacks the intrinsic mechanisms needed to replenish neurons and reestablish neuronal networks after acute injury or in response to the insidious loss of neurons seen in neurodegenerative diseases."

That is not to say that scientists failed to recognize that the brain must undergo some changes throughout life. After all, since the brain is the organ of behavior and the repository of learning and memory, when we acquire new knowledge or master a new skill or file away the remembrance of things past, the brain changes in some real, physical way to make that happen. Indeed, researchers have known for decades that learning and memory find their physiological expression in the formation of new synapses (points of connection between neurons) and the strengthening of existing ones; in 2000, the wise men of Stockholm even awarded a Nobel Prize in Physiology or Medicine for the discovery of the molecular underpinnings of memory.

But the changes underlying learning and memory are of the retail variety—strengthening a few synapses here and there or sprouting a few extra dendrites so neurons can talk to more of their neighbors, like a household getting an extra phone line. Wholesale changes, such as expanding a region that is in charge of a particular mental function or altering the wiring that connects one region to another, were deemed impossible.

Also impossible was for the basic layout of the brain to deviate one iota from the authoritative diagrams in anatomy textbooks: the visual cortex in the back was hardwired to handle the sense of sight, the somatosensory cortex curving along the top of the brain was hardwired to process tactile sensations, the motor cortex was hardwired to devote a precise amount of neural real estate to each muscle, and the auditory cortex was hardwired to field transmissions from the ears. Enshrined from clinical practice to scholarly monographs, this principle held that in contrast to the ability of the developing brain to change in significant ways, the adult brain is fixed, immutable. It has lost the capacity called neuroplasticity, the ability to change its structures and functions in a fundamental way.

To some extent, the dogma was understandable. For one thing, the human brain is made up of so many neurons and so many connections—an estimated 100 billion neurons making a total of some 100 trillion connections—that changing it even slightly looked like a risky undertaking, on a par with opening up the hard drive of a supercomputer and tinkering with a circuit or two on the motherboard. Surely that was not the sort of thing nature would permit and, in fact, something she might take steps to prevent. But there was a subtler issue. The brain contains the physical embodiment of personality and knowledge, character and emotions, memories and beliefs. Even allowing for the acquisition of knowledge and memories over a lifetime, and for the maturation of personality and character, it did not seem reasonable that the brain could or would change in any significant way. Neuroscientist Fred Gage, one of the researchers invited by the Dalai Lama to discuss the implications of neuroplasticity with him and other Buddhist scholars at the 2004 meeting, put the objections to the idea of a changing brain this way: "If the brain was changeable, then we would change. And if the brain made wrong changes, then we would change incorrectly. It was easier to believe there were no changes. That way, the individual would remain pretty much fixed."

The doctrine of the unchanging human brain has had profound ramifications, none of them very optimistic. It led neurologists to assume that rehabilitation for adults who had suffered brain damage from a stroke was almost certainly a waste of time. It suggested that trying to alter the pathological brain wiring that underlies psychiatric diseases, such as obsessive-compulsive disorder (OCD) and depression, was a fool's errand. And it

implied that other brain-based fixities, such as the happiness "set point" to which a person returns after the deepest tragedy or the greatest joy, are as unalterable as Earth's orbit.

But the dogma is wrong. In the last years of the twentieth century, a few iconoclastic neuroscientists challenged the paradigm that the adult brain cannot change and made discovery after discovery that, to the contrary, it retains stunning powers of neuroplasticity. The brain can indeed be rewired. It can expand the area that is wired to move the fingers, forging new connections that underpin the dexterity of an accomplished violinist. It can activate long-dormant wires and run new cables like an electrician bringing an old house up to code, so that regions that once saw can instead feel or hear. It can quiet circuits that once crackled with the aberrant activity that characterizes depression and cut pathological connections that keep the brain in the oh-god-something-is-wrong state that marks obsessive-compulsive disorder. The adult brain, in short, retains much of the plasticity of the developing brain, including the power to repair damaged regions, to grow new neurons, to rezone regions that performed one task and have them assume a new task, to change the circuitry that weaves neurons into the networks that allow us to remember, feel, suffer, think, imagine, and dream. Yes, the brain of a child is remarkably malleable. But contrary to Ramón y Cajal and most neuroscientists since, the brain can change its physical structure and its wiring long into adulthood.

The revolution in our understanding of the brain's capacity to change well into adulthood does not end with the fact that the brain can and does change. Equally revolutionary is the discovery of how the brain changes. The actions we take can literally expand or contract different regions of the brain, pour more juice into quiet circuits and damp down activity in buzzing ones. The brain devotes more cortical real estate to functions that its owner uses more frequently and shrinks the space devoted to activities rarely performed. That's why the brains of violinists devote more space to the region that controls the digits of the fingering hand. In response to the actions and experiences of its owner, a brain forges stronger connections in circuits that underlie one behavior or thought and weakens the connections in others. Most of this happens because of what we do and what we experience of the outside world. In this sense, the very structure of our brain—the relative size of different regions, the strength of connections be-

tween one area and another—reflects the lives we have led. Like sand on a beach, the brain bears the footprints of the decisions we have made, the skills we have learned, the actions we have taken. But there are also hints that mind-sculpting can occur with no input from the outside world. That is, the brain can change as a result of the thoughts we have thought.

A few findings suggest that brain changes can be generated by pure mental activity: merely thinking about playing the piano leads to a measurable, physical change in the brain's motor cortex, and thinking about thoughts in certain ways can restore mental health. By willfully treating invasive urges and compulsions as errant neurochemistry—rather than as truthful messages that something is amiss—patients with OCD have altered the activity of the brain region that generates the OCD thoughts, for instance. By thinking differently about the thoughts that threaten to send them back into the abyss of despair, patients with depression have dialed up activity in one region of the brain and quieted it in another, reducing their risk of relapse. Something as seemingly insubstantial as a thought has the ability to act back on the very stuff of the brain, altering neuronal connections in a way that can lead to recovery from mental illness and perhaps to a greater capacity for empathy and compassion.

It is this aspect of neuroplasticity—research showing that the answer to the question of whether we can change is an emphatic yes—that brought five scientists to Dharamsala this autumn week. Since 1987, the Dalai Lama had opened his home once a year to weeklong "dialogues" with a handpicked group of scientists, to discuss dreams or emotions, consciousness or genetics or quantum physics. The format is simple. Each morning, one of the five invited scientists sits in an armchair beside the Dalai Lama at the front of the room used for ordinations and describes his or her work to him and the assembled guests—in 2004, a couple of dozen monks and monastery students, as well as scientists who had participated in previous dialogues. It is nothing like the formal papers scientists are accustomed to presenting at research conferences, where they barrel through their findings to a rapt (they hope) audience. Instead, the Dalai Lama interrupts whenever he needs a clarification, whether for a point of translation (the scientists speak in English, which the Dalai Lama understands well, but a casually thrown-off scientific term such as *hippocampus* or *BRDU* will prompt a hurried tête-à-tête with one of his interpreters) or because one of the scien-

tific findings reminds him of a point of Buddhist philosophy. The morning is punctuated by a tea break, during which the Dalai Lama either stays in the room for informal conversation with the scientists or takes a breather, and everyone else decamps to a huge adjacent room for tea and cookies. In the afternoon, the Dalai Lama and the Buddhist scholars he has invited respond to what the scientist has presented that morning, explaining what Buddhism teaches about the topic or suggesting further experiments to which Buddhist contemplatives might lend their minds and brains.

This time, the scientists were those working at the frontiers of neuroplasticity. Fred Gage, of the Salk Institute in La Jolla, California, works with laboratory animals; he has made seminal discoveries in how the environment can change their brains, in ways applicable to people. He also led a study on human subjects, demolishing the dogma that the adult brain does not generate new neurons. Michael Meaney, from Montreal's McGill University, has toppled the idea of genetic determinism. Also working with lab animals, he showed that the way a mother rat treats her babies determines which genes in the baby's brain are turned on and which are turned off, with the result that the genes with which it is born become merely an opening gambit on nature's part: the animal's traits—fearful or shy, neurotic or well adjusted—are shaped by maternal behavior, something that also has relevance for people. Helen Neville, of the University of Oregon, has done as much as any scientist to show that brain diagrams depicting what region does what should be printed in erasable ink. In work with people who are blind or deaf, she discovered that even something as seemingly fundamental, as hardwired, as the functions of the visual cortex and the auditory cortex can be completely overturned by the life someone leads. Phillip Shaver, of the University of California–Davis, is one of the leaders in the field of psychology called attachment theory. He discovered that people's sense of emotional security, based on their childhood experiences, has a powerful effect not only on their adult relationships but also on seemingly unrelated behaviors and attitudes such as their feelings about people who come from different ethnic groups and their willingness to help a stranger. For these four scientists, it was their first trip to Dharamsala and their first meeting with the Dalai Lama.

Richard Davidson was the veteran of these dialogues. More than that, however, his research on the science of emotions had grown to include

studies of Buddhist contemplatives, men who devote their days to meditation. The Dalai Lama had helped arrange for Buddhist monks and yogis to trek all the way to Davidson's lab at the University of Wisconsin–Madison so he could study their brains. His work was beginning to show the power of the mind to change the brain. He would orchestrate the meeting, introducing each of the scientists for their morning presentation and leading the discussion each afternoon.

"Of all the concepts in modern neuroscience, it is neuroplasticity that has the greatest potential for meaningful interaction with Buddhism," Davidson said.

Buddhism and Science

Although science and religion are often portrayed as chronic opponents and even enemies, that misses the mark for science and Buddhism. There is no historic antagonism between the two, as there has been between science and the Catholic Church (which put Copernicus's work on the Index of forbidden books) and, lately, science and fundamentalist Christianity (which, in the United States, has used the wedge issue of creationism to argue that science is "just" another way of knowing). Instead, Buddhism and science share the goal of seeking the truth, with a lowercase *t.* For science, truth is always tentative, always subject to refutation by the next experiment; for Buddhism—at least, as the Dalai Lama sees it—even core teachings can and must be overturned if science proves them wrong. Perhaps most important, Buddhist training emphasizes the value of investigating reality and finding the truth of the outside world as well as the contents of one's mind. "Four themes are common to Buddhism at its best: rationality, empiricism, skepticism, and pragmatism," says Alan Wallace, who spent years as a Buddhist monk in Dharamsala and elsewhere before turning in his robes to become a Buddhist scholar and who is a longtime participant in the dialogues between scientists and the Dalai Lama. "His Holiness embodies these. He often says with delight that if there is empirical evidence that contradicts something in Buddhism, 'Into the garbage!' He is quite adamant that Buddhism has to yield to rational argument and empiricism."

Consonances between Buddhism and science were recognized as early as 1889, when Henry Steele Olcott argued in *Buddhist Catechism* that Buddhism is "in reconciliation with science," that there is "an agreement between Buddhism and science as to the root idea." Olcott based this on the fact that Buddhism, like science, teaches "that all beings are alike subject to universal law." By this reasoning, says José Ignacio Cabezón, a former Buddhist monk and now a scholar of religion and science at the University of California–Santa Barbara, "Buddhism and science are in agreement because they subscribe to the view that there are natural laws that govern the development of both persons and the world." In 1893, at the World Parliament of Religions in Chicago, part of the World's Columbian Exposition, Buddhist leader Anagarika Dharmapala of Sri Lanka spoke passionately of how Buddhism, not Christianity, could bridge the chasm that for centuries had divided science and religion. He based his hope on Buddhism's status as a nontheistic tradition, one with no creator god and with "no need for explanations that went beyond that of science, there being no need for miracles or faith," Cabezón explains. As Alan Wallace puts it, "Buddhism is not a religion; it is a philosophy. It is not some eastern version of Christianity or Judaism. Buddhism does not culminate in faith, as the Abrahamic traditions do. It culminates in insight."

Some scholars have gone so far as to proclaim Buddhism the "Religion of Science." As the Sri Lankan scholar K. N. Jayatilleke argued in his essay "Buddhism and the Scientific Revolution" in the late 1950s, Buddhism "accords with the findings of science" and "emphasizes the importance of a scientific outlook" in that "its specific dogmas are said to be capable of verification." Like science, Buddhism is "committed to critically (and not dogmatically) establishing the existence of universal laws," José Cabezón says.

Which is not to deny that some silliness swirls around efforts to find consonances between science and Buddhism. Through the decades, there have been claims that Buddhism *is* science, that the Buddha was the founder of psychology, that Buddhism discovered the size of elementary particles and of the universe, that modern physics merely confirms what Buddhist sages knew centuries ago. But while such assertions are over the top, a growing number of neuroscientists are at least open to the notion that Buddhism has something substantive to say about the mind. If so, then

Buddhism and science both stand to benefit from their interaction. "Science stands to gain by being pushed to consider mind or consciousness nonmechanistically, or by having to confront extraordinary inner mental states that are not normally within the purview of its investigations," says José Cabezón. "Buddhists stand to profit by gaining access to new facts concerning the material world (body and cosmos)—facts that have lain outside of traditional Buddhist speculation due to technological limitations."

The discoveries of neuroplasticity, in particular, resonate with Buddhist teachings and have the potential to benefit from interactions with Buddhism. The reason gets to the very core of Buddhist belief. "Buddhism defines a person as a constantly changing dynamic stream," says Matthieu Ricard, a French-born Buddhist monk. A veteran of the scientific dialogues with the Dalai Lama, he is anchoring the "Buddhist side" of the 2004 meeting.

Even scholars who were not involved in the meeting—but who have followed the dialogues closely—point out the consonances between Buddhist teaching and the idea, and potential, of neuroplasticity. "There are many strong parallels between the neuroscientific findings and the Buddhist narrative," says Francisca Cho, a Buddhist scholar at George Washington University. "Buddhism's is a story of how we are in pain and suffering and how we have the power to change that. The scientific findings about neuroplasticity parallel the Buddhist narrative of enlightenment because they show that, although we have deeply ingrained ways of thinking and although the brain comes with some hardwiring, we also have the possibility of changing. The idea that we are constantly changing means there is no intrinsic nature to the self or the mind, which is what Buddhism teaches. Instead, both self and mind are extremely plastic. Our activities inform who we are; as we act, so we shall become. We are products of the past, but because of our inherently empty nature, we always have the opportunity to reshape ourselves."

The discovery that mere thought can alter the very stuff of the brain is another natural point of connection between the science of neuroplasticity and Buddhism. Buddhism has taught for twenty-five hundred years that the mind is an independent force that can be harnessed by will and attention to bring about physical change. "The discovery that thinking something produces effects just as doing something does is a fascinating

consonance with Buddhism," says Francisca Cho. "Buddhism challenges the traditional belief in an external, objective reality. Instead, it teaches that our reality is created by our own projections; it is thinking that creates the external world beyond us. The neuroscience findings harmonize with this Buddhist teaching."

Buddhist narratives have another consonance with the discoveries of neuroplasticity. They teach that by detaching ourselves from our thoughts, by observing our thinking dispassionately and with clarity, we have the ability to think thoughts that allow us to overcome afflictions such as being chronically angry. "You can undergo an emotional reeducation," Cho says. "By meditative exertion and other mental exercises, you can actively change your feelings, your attitudes, your mind-set."

Indeed, Buddhism believes that the mind has a formidable power of self-transformation. When thoughts come to the untrained mind, they can run wild, triggering destructive emotions such as craving and hatred. But mental training, a core of Buddhist practice, allows us "to identify and to control emotions and mental events as they arise," says Matthieu Ricard. Meditation, the most highly developed form of mental training, "is about coming to a new perception of reality and of the nature of mind, about nurturing new qualities until they become integral parts of our being. If we place all our hopes and fears in the outside world, we have quite a challenge, because our control of the outside world is weak, temporary, and even illusory. It is more within the scope of our faculties to change the way we translate the outside world into inner experience. We have a great deal of freedom in how we transform that experience, and that is the basis for mental training and transformation."

And why does the Dalai Lama hope to contribute to scientific understanding, whether by engaging in these dialogues with researchers or by encouraging Buddhist monks to lend their brains to science? "His Holiness believes that today's dominant worldview is the scientific one, and he wants to keep Buddhism growing and developing by engaging with science," says Thupten Jinpa, a Tibetan Buddhist scholar who earned a Ph.D. in religious studies from Cambridge University in 1989. The Dalai Lama's primary English translator and a collaborator on several of his books, Jinpa directs the Institute of Tibetan Classics, in Montreal, editing and translating Tibetan texts. "His Holiness," he says, "hopes to inspire a younger genera-

tion of Buddhist scholars to engage with science. But also, he is personally curious."

Of Timepieces and Telescopes

That curiosity dates from his youth. The boy who would become the fourteenth Dalai Lama was born on July 6, 1935, the fifth of nine children in a family of subsistence farmers who used cattle to plow their barley fields on the high Tibetan plateau in the northeastern province of Amdo and to pound grains out of tough husks. At the age of two, Tenzin Gyatso was recognized, after a nationwide search, as the reincarnation of the thirteenth Dalai Lama, Thubten Gyatso, who had died in 1933. He was formally installed as the head of state of Tibet on February 22, 1940. Science was unknown in his world, and when he looked back on his youth seventy years later, the only technology he recalled was the rifles carried by local nomads.

Between lessons in reading, writing, rote memorization of Buddhist rituals and scriptures, and Buddhist philosophy, the young Dalai Lama amused himself by embarking on sporadic treasure hunts in the one thousand rooms of Potala Palace in the capital of Lhasa. The palace held what he termed "assorted oddities" belonging to his predecessors, especially the thirteenth Dalai Lama. In a poignant foreshadowing of the current Dalai Lama's own desperate escape from Tibet after the Chinese invasion, the thirteenth Dalai Lama had fled Tibet in 1900, when word came that the armies of the last Chinese emperor were poised to invade. He spent a brief time in India, long enough to awaken to how the world beyond Tibet was charging ahead into the new century. Upon his return to Tibet, he established several political and social reforms, including mail service and secular education, as well as technological ones: a telegraph system and Tibet's first electric lights, powered by a small generating plant. He also brought back to the palace a fascination with mechanical objects, including those given to him by a British political officer posted to nearby Sikkim, Sir Charles Bell.

So when the fourteenth Dalai Lama explored the palace's chambers, he came upon an old brass telescope, a mechanical clock, two film projectors,

a simple pocket watch, and three automobiles—all of which had been carried across the mountains in pieces from India, on the backs of donkeys, mules, and porters, since there were no roads fit for cars across the Himalayas or, indeed, anywhere in Tibet beyond Lhasa. The clock especially intrigued him. It perched atop a sphere that made a complete rotation every twenty-four hours and was covered with mysterious patterns. One day, paging through his geography books, the Dalai Lama realized that the drawings on the sphere were a map of the world, and the globe's rotation showed the sun's apparent movement from east to west across the sky. Other tokens of technology came the Dalai Lama's way as gifts. In 1942, a group of Americans presented him with a gold pocket watch. British visitors gave him a train set and a pedal car.

"There was a time, I remember very clearly, when I would rather fiddle with these objects than study philosophy or memorize a text," the Dalai Lama wrote in his 2005 book *The Universe in a Single Atom.* "They hinted at a whole universe of experience and knowledge to which I had no access and whose existence was endlessly tantalizing."

Indeed, he derived his greatest enjoyment of these gifts not from using them in the usual way but by taking them apart. He disassembled his wristwatch and managed to get all the pieces back together in working order. He took apart his toy cars and boats, rooting around for the mechanisms that made them work. As a teenager, he scrutinized an old movie projector that was powered by a hand crank, wondering how a spinning wire coil could generate electricity. There was no one in the palace he could ask, so he took it apart, too, and gazed at the pieces hour after hour, finally figuring out that a wire coil rotating around a magnet indeed generates an electric current. Thus began a lifelong love of dismantling and reassembling gadgets, something at which he grew adept enough to become the go-to man for friends in Lhasa who owned clocks or watches. (He never managed to repair his cuckoo clock after his cat attacked the poor bird, however.) Emboldened by what he took as evidence of a mechanical knack, the young Dalai Lama set his mind on fathoming the workings of his predecessor's automobiles, though he confined himself to learning to drive rather than turning the cars into a pile of parts. He did not lack for ingenuity, however. When he had a minor accident and broke the left headlight, he was terrified of what the palace attendant in charge of the fleet would say and quickly

managed to procure a replacement. But while the original was of frosted glass, the replacement was clear. So he coated it with melted sugar.

His exalted status had a few disadvantages, notably the Tibetan custom that the Dalai Lama must remain sequestered in Potala Palace. Yearning for a glimpse of the outside world, he seized on the thirteenth Dalai Lama's telescope. In the daytime, he turned it on the hustle and bustle of the town spread out below the palace. At night, though, he turned it to the stars, asking his attendants the names of the constellations. On a night with a full moon, he peered at the lunar surface, where Tibetan folklore says a rabbit resides (akin to the Americans' and Europeans' "man in the moon"). Seeing shadows, he excitedly called over his two tutors to see for themselves. Look, he exclaimed; the shadows on the moon belie the fourth-century Buddhist cosmology that holds that the moon is a heavenly body like the Sun and other stars, radiating with light from an internal source. The moon is clearly "just a barren rock, pocked with craters," he saw, and the shadows that fall across its uneven surface proof that the moon, like Earth, is illuminated by the reflected light of the Sun. His own empirical observation had disproved an ancient Buddhist teaching. The discovery left a lasting impression. Observation, he realized, can challenge traditional Buddhist teachings.

"Looking back over my seventy years of life, I see that my personal encounter with science began in an almost entirely prescientific world where the technological seemed miraculous," he wrote. "I suppose my fascination for science still rests in an innocent amazement at the wonders of what it can achieve."

To the Dalai Lama, whose lessons included nary a whiff of math, physics, chemistry, or biology—and who had no clue, as a child, that these subjects even existed—the gadgets and rudimentary technologies that fascinated him *were* science. But slowly, once he was formally enthroned as the temporal leader of Tibet on November 17, 1950, and began visiting China and India, he came to understand that science is not merely the foundation for gadgets but a coherent way of questioning and understanding the world. It was this facet of science, he says today, that intrigued him and in which he saw profound similarities to Buddhism.

Just as science observes the minutiae of the world and the beings and objects within it, constructing theories and making predictions, refining or

jettisoning a theory when experiments contradict it, so the Buddhism he learned in his contemplative practice and philosophical lessons is imbued with the same spirit of open-minded inquiry. "Strictly speaking," the Dalai Lama has written, "in Buddhism scriptural authority cannot outweigh an understanding based on reason and experience."

That tradition began with the Buddha himself, who admonished his acolytes twenty-five hundred years ago not to accept the authority of his own words, as set down in the scriptures, nor the rightness of his teachings simply out of respect for him. *Test* the truth of what I say, he told them, through the application of your reason and your observations of people and the world around you. "Therefore, when it comes to validating the truth of a claim, Buddhism accords the greatest authority to experience, with reason second and scripture last," the Dalai Lama has said. If science discovers that a belief of Buddhism is wrong, that it violates an indisputable truth of science, he has said repeatedly, then Buddhism must abandon that view or scriptural teaching even if it has prevailed for millennia. "Buddhism must accept the facts," he says. For instance, Buddhist physics, which holds that form, taste, smell, and tactility are basic constituents of matter, has to be modified, he says.

On March 17, 1959, the Dalai Lama fled Tibet after an uprising against the occupying Chinese failed. Some eighty thousand Tibetans eventually followed him into exile, many settling in or near Dharamsala, where he made his home and established the Tibetan government in exile. During his first three decades in exile, almost everything the Dalai Lama knew about science came from news seeping into Dharamsala—through the BBC, *Newsweek,* and the occasional astronomy textbook. But by the late 1980s, his curiosity was turning into something more pressing. Science's "inevitable dominance in the modern world fundamentally changed my attitude to it from curiosity to a kind of urgent engagement," he wrote. "The need to engage with this powerful force in our world has become a kind of spiritual injunction as well. The central question . . . is how we can make the wonderful developments of science into something that offers altruistic and compassionate service for the needs of humanity and the other sentient beings with whom we share this earth."

In 1983, the Dalai Lama traveled to Austria for a conference on consciousness. There he met Francisco Varela, a thirty-seven-year-old Chilean-

born neuroscientist who had begun practicing Buddhism in 1974. The Dalai Lama had never met an eminent neuroscientist who was also knowledgeable about Buddhism, and the young researcher and the older Buddhist hit it off immediately. Even with his busy schedule, the Dalai Lama told Varela, he wished he could have such conversations more often.

The Mind and Life Institute

The year after Varela met the Dalai Lama, he heard about a plan that Adam Engle, an entrepreneur in California, was working on. In 1983, Engle was serving on the board of the Universal Education Organization, which had been founded by Lama Thubten Yeshe. At one board meeting, someone mentioned that His Holiness was supposedly keenly interested in science. What an odd pairing, Engle thought: the spiritual head of Tibetan Buddhism, leader of the Tibetan government in exile—and science? I wonder if it's true. As the meeting ended, he decided that if it were, he wanted to "put some energy" into making the Dalai Lama's interest in science something more than a passing fancy.

Engle, who had become a practicing Buddhist eight years before, began asking acquaintances in California's Buddhist community about the Dalai Lama's rumored interest in science. To a person, they all assured Engle that His Holiness loved science. The idea began gestating in Engle's mind. A year later, he attended a public teaching by the Dalai Lama in Los Angeles with a friend and colleague, Michael Sautman. As he waited for the doors to open, Sautman introduced him to the Dalai Lama's youngest brother, Tendzin Choegyal (Ngari Rinpoche), who was part of His Holiness's entourage. As Engle shook his hand, he recalled more than twenty years later, "part of me said, 'Don't bother him with this now,' while another part said, 'It's now or never.' " The second voice won. Keeping Rinpoche's hand in a desperation grip, Engle scraped up the courage to blurt out that he had heard that His Holiness was interested in science and that he would like to "organize something." Rinpoche offered to meet after the teaching in the lounge of the Century Plaza Hotel.

At six o'clock that evening, Rinpoche swept into the lounge, and Engle plunged right in. He had heard through the Buddhist grapevine, he said,

that His Holiness was interested in science. If that were so, he'd love to try to set up something, perhaps a meeting where the Dalai Lama could hear from and talk with scientists. But please be sure to explain to him that this was not to be yet another event to which the Dalai Lama lent his name and perhaps a few minutes of his time for a keynote address. I'll do this, Engle explained, only if His Holiness wants to be a full participant. Rinpoche agreed to talk to his brother.

Two days later, at another of the Dalai Lama's teachings, Rinpoche told Engle that the Dalai Lama was truly interested in participating in something substantive about science. Engle began brainstorming just what, exactly, he might put together. He assumed the subject would be something in physics; Fritjof Capra's book *The Tao of Physics* had just introduced millions of readers to the notion of a consonance between the wisdom of the East and the discoveries of quantum physics. In early 1985, Engle and Sautman visited Capra in Berkeley, but the writer was lukewarm to the idea of convening a meeting between the Dalai Lama and physicists to explore some of the ideas in his book. There seemed to be an unending stream of New Agey meetings, Capra groused, and he was getting tired of them: people get up and make speeches, and nothing happens next. Engle left, no closer to knowing what he was supposed to be organizing.

Soon after, Francisco Varela, the neuroscientist who had met the Dalai Lama in Austria, phoned Engle from Paris. He had heard that Engle was trying to put together a meeting between the Dalai Lama and a group of scientists. He told Engle about his own chance meeting with the Dalai Lama, who invited Varela to continue the dialogue. But Varela wasn't sure how to do that. Hearing of Engle's own inchoate plans, he knew one thing. *"Adam,"* he said, *"you don't want to do this on physics; cognitive science makes much more sense."*

Varela knew there would be hurdles. Soon after he began practicing Buddhism, he had embraced meditation as a tool of cognitive research. He believed that cognitive science, a fusion of psychology and neuroscience that attempts to parse the workings of the mind and brain, could benefit from introspective accounts of mental activity—but not haphazard accounts from untrained observers. Just as casual observations of, say, how the leg moves are unlikely to yield any reliable insights into muscle metabolism, so casual observations of what one's mind is doing would rightly be suspect. But a trained observer, Varela thought, was a different story: such

a person could turn meditation into a tool of cognitive research. By giving practitioners greater access to the contents and processes of their minds, he thought, meditation could augment the traditional study of the mind and brain, providing a reliable first-person account of mental activity.

His proposal was not exactly embraced by the neuroscience world, many of whose scientists regarded introspection as hardly better than entrails when it came to understanding the workings of the mind. When Varela met with Engle, he therefore warned him about the importance of inviting scientists who would be open-minded about what the first-person accounts of contemplatives, and centuries of Buddhist scholarship on the mind, could contribute to scientific understanding. Nothing would be accomplished if the scientists came gunning for Buddhism.

In March 1986, after more than a year of corresponding with the Dalai Lama's office, Engle flew to New Delhi and, after an overnight train and a three-hour car ride that took him past more traffic of the bovine than the vehicular variety, arrived in Dharamsala. He walked to the gate of the Dalai Lama's compound, just up the hill from the town's central intersection, and asked to see the Dalai Lama's secretary, Tenzin Geyche Tethong. The guard called the office, and soon a young assistant trotted down the curving asphalt walkway. Engle showed him his sheaf of correspondence with the Dalai Lama's office, in which letters had passed back and forth about setting up some sort of meeting with scientists, hoping that would distinguish him from every other acolyte who showed up wanting some contact with His Holiness. The poor kid was so confused about who exactly Engle was and what he wanted that he gave up and led him up to see Tenzin Geyche.

In the stucco building where the Dalai Lama keeps his private office, Engle introduced himself to Tenzin Geyche and described his months of correspondence with the office. It was the first Tenzin Geyche, who had just recently taken the post of secretary, had heard about any proposed meeting with the Dalai Lama and scientists. Engle asked for an audience with the Dalai Lama. I'll get back to you, Tenzin Geyche said; where are you staying? I haven't found the place yet, Engle answered, but I'll be at Kashmir Cottage. Walking back down the path and past the security booth at the bottom of the hill, Engle wandered the winding streets of Dharamsala until

he came upon Kashmir Cottage, which was owned and run by Tendzin Choegyal and had been the home of the Dalai Lama's mother until her death.

Tendzin Choegyal remembered Engle from the Century Plaza lounge in Los Angeles eighteen months before. Would you talk to Tenzin Geyche about the Dalai Lama's interest in having this meeting with scientists? Engle asked. Two days later, Engle had his audience with the Dalai Lama. He explained what he and Francisco Varela had in mind, and after listening intently, the Dalai Lama said that this was something he very much wanted to do. But Engle had a question: "What's in it for you?" He was personally interested in science and wanted to keep learning about it, the Dalai Lama said. He also wanted to introduce science into the monastic curriculum. He was deeply aware that, in the modern world and especially in the West, science is the dominant mode of discovering reality; the monastery students needed to know about it, for understanding science was crucial to the continued vitality of Buddhism.

Things moved quickly. Varela met with the Dalai Lama in Paris that June, confirming his interest in the proposed meeting, and Engle got a formal okay on it from the Dalai Lama's secretary. He returned to Dharamsala to work out dates. How much time do you want? Tenzin Geyche asked. A week in October, Engle replied. Tenzin Geyche laughed. That's impossible, he said; we're here for only two weeks next October, and the only thing His Holiness has ever done for a full week is teach Buddhism. Engle, dejected, returned to Kashmir Cottage. But two days later, a letter arrived from the private office. He got the exact dates he'd proposed—and the full week of the Dalai Lama's time.

In October 1987, the Dalai Lama hosted the first conference of what Engle and Varela had named the Mind and Life Institute, in Dharamsala. Five scientists and one philosopher engaged him in seven days of informal give-and-take on cognitive science and Buddhism. The format became the model for every subsequent dialogue between the Dalai Lama and scientists: each scientist presenting his or her work to the Dalai Lama, followed by exchanges between the scientists and the Dalai Lama and other invited Buddhist scholars.

Just a few years before the Mind and Life meetings began, the Dalai Lama recalled, he had had a conversation with an American woman married to a

Tibetan. She cautioned him that science has a long history of "killing" religion and thus might threaten the survival of Buddhism. He should not befriend these people, she warned. He thought otherwise. Recalling that first Mind and Life meeting years later, he says, he "leapt at this idea." He saw the dialogues with leading scientists as an opportunity to learn about the latest scientific thinking, of course, but also as part of his mission to open Tibetan society and culture to the modern world. He therefore ordered that science be part of the curriculum in the children's schools and even in the monastic colleges, whose focus is classical Buddhist thought and whose students are all monks-in-training. "If as spiritual practitioners we ignore the discoveries of science, our practice is also impoverished," he later wrote.

The Dalai Lama has become much more than the leader of the Tibetan people, the spiritual leader of Tibetan Buddhism, and the head of the Tibetan government in exile. He is also an international icon; symbol of forgiveness, enlightenment, peace, and wisdom; able to attract throngs to the "teachings" he offers in locales from New York's Central Park to the holiest sites of Buddhism in India. To a small but growing group of scientists, he is also a bridge between the world of spirituality and the world of science, someone whose expertise in mental training might offer Western science a perspective that has been lacking in its investigations of mind and brain.

That brought him an invitation to address the annual meeting of the Society for Neuroscience in 2005—and more controversy than he counted on. Some five hundred members signed a petition protesting his appearance, arguing that religion has no place at a scientific conference. (Many of the leaders of the protest were Chinese-born scientists, which fueled rumors that the protest was more political than scientific.) Even the Dalai Lama recognized the seeming incongruity of his association with neuroscience. "So what is a Buddhist monk doing taking such a deep interest in neuroscience?" he asked rhetorically. He offered an answer in his most recent book. "Spirituality and science are different but complementary investigative approaches with the same greater goal, of seeking the truth," he wrote. Specifically, he told the neuroscientists, although Eastern contemplative practices and Western science arose for different reasons and with different goals, they share an overriding purpose. Both Buddhists and sci-

entists investigate reality: "By gaining deeper insight into the human psyche, we might find ways of transforming our thoughts, emotions and their underlying properties so that a more wholesome and fulfilling way can be found."

It is little wonder that neuroplasticity, the topic of the 2004 meeting organized by the Mind and Life Institute, resonated with the Dalai Lama. He is intrigued that the Buddhist understanding of the possibility of mental transformation has parallels in the plasticity of the brain. "The Buddhist terms in which this concept is couched are radically different from those used by cognitive science, but what is significant is that both perceive consciousness as highly amenable to change," he has written. "The concept of neuroplasticity suggests that the brain is highly malleable and is subject to continual change as a result of experience, so that new connections between neurons may be formed or even brand-new neurons generated." And as he wrote in his 1998 bestseller *The Art of Happiness,* "The wiring in our brains is not static, not irrevocably fixed. Our brains are also adaptable."

Not static. Not fixed. Subject to continual change. Adaptable. Yes, the brain can change, and that means that we can change. It is not easy. As we will see, neuroplasticity is impossible without attention and mental effort. At the risk of invoking an old joke, in order to change, you have to *want* to change (whether or not you are a lightbulb). But if the will is there, the potential seems immense. Depression and other mental illnesses can be treated by enlisting the mind to change the brain, not by flooding it with problematic drugs. A brain afflicted with dyslexia can change into one that reads fluently, merely by repeatedly changing the sensory input it receives. A brain with no special ability in sports or music or dance might be induced to undergo a radical rezoning, devoting more of its cortical real estate to the circuitry that supports these skills.

The Dalai Lama has thrown his personal and official resources into supporting research into neuroplasticity because it resonates so well with Buddhism's wish that all sentient beings be free from suffering. It is not so far-fetched a goal: a brain whose existing circuitry leads to suspicion and xenophobia might, through disciplined effort and commitment to self-improvement, be rewired to respond with compassion and altruism. Because the science is so new, the limits of neuroplasticity are largely unmapped. But there is no question that the emerging science of neuroplas-

ticity has the potential to bring radical changes, to both individuals and the world, raising the possibility that we could train ourselves to be kinder, more compassionate, less defensive, less self-centered, less aggressive, less warlike. This world of possibilities opened up by the discoveries of neuroplasticity is why scientists and Buddhist scholars met that autumn in Dharamsala.

Just a word about the organization of this story. The five researchers who met with the Dalai Lama have made seminal contributions to the revolutionary science of neuroplasticity. Their stories are told in chapters 3, 4, 7, 8, and 9. But it's impossible to grasp the extent of the brain's power of neuroplasticity without knowing about other discoveries; those are described in chapters 2, 5, and 6.

I began by quoting Ramón y Cajal's view that "the nerve pathways are something fixed, ended, and immutable." Most scientists who quote Ramón y Cajal stop there. But in fact, Ramón y Cajal continued, "It is for the science of the future to change, if possible, this harsh decree." As we will now see, it did.