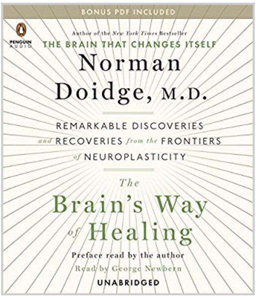

The Brain's Way of Healing: Remarkable Discoveries and Recoveries from the Frontiers of Neuroplasticity

By Norman Doidge

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His revolutionary new book shows, for the first time, how the amazing process of neuroplastic healing really works. It describes natural, non-invasive avenues into the brain provided by the forms of energy around us—light, sound, vibration, movement—which pass through our senses and our bodies to awaken the brain's own healing capacities without producing unpleasant side effects. Doidge explores cases where patients alleviated years of chronic pain or recovered from debilitating strokes that had plateaued; children on the autistic spectrum or with learning disorders normalizing; symptoms of multiple sclerosis, Parkinson's disease, and cerebral palsy radically improved, and other near-miracle recoveries. And we learn how to vastly reduce the risk of dementia with simple approaches anyone can use.

For centuries it was believed that the brain's complexity prevented recovery from damage or illness. *The Brain's Way of Healing* shows that this very sophistication is the source of a unique kind of healing. As he did so lucidly in *The Brain That Changes Itself*, Doidge uses stories to present exciting, cutting-edge science with practical real-world applications, and principles that everyone can apply to improve their brain's performance and health.

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Editorial Review

Review
#1 *Globe and Mail* Nonfiction Bestseller
#1 *Toronto Star* Nonfiction Bestseller

Praise for *The Brain's Way of Healing*

"Brilliant and highly original. Neurology used to be considered a depressing discipline with patients often displaying fascinating but essentially untreatable symptoms and disabilities. Drawing on the last three decades of research, Doidge challenges this view, using vivid portraits of patients and their physicians. The book is a treasure trove of the author's own deep insights and a clear bright light of optimism shines through every page."
—V. S. Ramachandran, MD, PhD, neurologist, neuroscientist, and author of *The Tell-Tale Brain* (W. W. Norton, 2011), Director, UCSD Center for Brain and Cognition

"A tour de force. In one of the most riveting books on the human brain and its mystery powers ever written, Doidge addresses the role of alternative medical therapies to reset and re-sync the dynamic patterns of 'energy in our brain, whit the ability to restore relatively normal health to those whose fate seems hopeless. . . . These are people that traditional medicine all but abandoned as . . . untreatable. But they were rescued. . . . It's possible to start anywhere in the book and be mesmerized."
—*Huffington Post*

"An exciting overview of powerful new neuroscience theories that connect mind, body, and soul . . . In this age of distraction and unnatural environments and actions—like staring at screens all day—brain science offers all kinds of useful techniques to care for our infinitely complex selves. Norman Doidge's work is a Michelin Guide to this hopeful new trove of knowledge and insight."
—*Boston Globe*, USA

"Stunning . . . *The Brain's Way of Healing* is another groundbreaking book by Norman Doidge.? His style keeps you going into the deep dark secrets?of how the brain works. . . . [H]is reframing of remarkable treatments?that I had categorized as gimmicky left me fascinated and humbled. He brings a whole new level of insight into the body, brain, mind connection?that will impact any reader."
— John J. Ratey, MD, Clinical Associate Professor of Psychiatry,?Harvard Medical School and author of *Driven to Distraction*

"Bold, remarkable . . . paradigm challenging. *The Brain's Way of Healing* is brilliantly organized, scientifically documented, and a beautifully written narrative that captivates the reader, who is left with the profound message that the brain, similar to other organs, can heal."
—Stephen W. Porges, PhD, Indiana University Bloomington and author of *The Polyvagal Theory*

"Doidge's book is filled with compelling stories about the power of ingenious technologies and disciplined awareness methods generated by innovators who transcended their own brain challenges, and who now use them to help others make radical improvements in conditions often deemed hopeless. It points to a future of remarkable and unprecedented brain healing."
—Martha Herbert, MD, PhD, Neurologist, Harvard Medical School, and Massachusetts General Hospital,

author of *The Autism Revolution*

"*The Brain's way of Healing* is a stunner—the sort of book you want to read several times, not because it is difficult to understand, but because it opens up so many novel and startling avenues into our potential to heal. Norman Doidge enthralls us with a rich combination of lucidly explained brain research and pioneering new (and some not so new, but not widely known) approaches to recovery. With an eloquence reminiscent of Oliver Sacks, Doidge bolsters the latest advances in brain science with a series of extraordinary case histories of people for whom all hope seemed to be lost, but who healed as a result of great personal courage, and by changing the ways their bodies and brains processed sensations and movement. This hopeful book demonstrates that a variety of sensory inputs—light, sound, electricity, vibration, movement, and thought—can awaken the brain's attention processors, and thereby allow even the most afflicted to (re)gain ownership of their lives.
—Bessel van der Kolk MD, Medical Director, the Trauma Center, Brookline MA; Professor of Psychiatry, Boston University School of Medicine; Author of *The Body keeps the Score: Mind, Brain and Body in the healing of Trauma*

"The book offers real hope to individuals suffering from diverse chronic conditions. It shows in terms of graphic personal stories that we truly do not yet know the limits of what is possible in rehabilitation. The book also has a number of creative integrations of the data that will be of interest to neuroscientists."
—Edward Taub, Ph.D., Behavioral Neuroscientist, University Professor,University of Alabama at Birmingham, Director, UAB CI Therapy Research Group and Taub Training Clinic

"Everyone who has a brain could benefit from reading Doidge's book."
—*The Columbus Dispatch*

"A vivid, robust and optimistic read . . . an essential addition to our growing understanding of the mind-brain-body connection. Doidge argues quite convincingly that when the brain is damaged or incompletely formed, whether from stroke, multiple sclerosis, traumatic brain injury, autism, ADHD or a host of other conditions, it's entirely possible to "rewire" the circuits by training a different part of the brain to take over the task. . . . He's positively elegant in his crystalline explanations of brain science for a lay audience."
—*Toronto Star*, Canada

"This is a book of miracles: an absorbing compendium of unlikely recoveries from physical and mental ailments offers evidence that the brain can heal. Fascinating . . . brings to mind Oliver Sacks."
—*Guardian*

"Dazzling . . . In friendly vignettes reminiscent of Oliver Sacks's case studies, Doidge chronicles the heroic efforts of patients with a wide variety of apparently intractable ailments, from chronic pain to multiple sclerosis. . . . Each of Doidge's examples suggests tangible treatment ideas for patients who may have thought they were out of options. Doidge's penchant for considering unconventional approaches to healing offers hope for all."
—*Bookpage*, USA

"Beautifully written . . . inspiring . . . merging scientific information into timeless and fascinating personal stories . . . *The Brain's Way of Healing* grabs onto the reader at once and compels them to keep reading. This is an important and encouraging book."
—*The Vancouver Sun*, Canada

"Exhilarating science . . . In an era of ever-increasing medicalisation of the human mind, and the medication

of it, the appeal of neuroplasticity outlined by Doidge is addictive. It is inspiring, page-turning stuff."
—*Sunday Times*, London

"A fascinating study on brain science that shows the way to major therapeutic discoveries."
—Library Journal

From the Hardcover edition.

About the Author
NORMAN DOIDGE, M.D., is a psychiatrist, psychoanalyst, and *New York Times* bestselling author. He is on the research faculty at Columbia University's Center for Psychoanalytic Training and Research in New York City and on the faculty of the University of Toronto's Department of Psychiatry as well. He lives in Toronto.

Note to the Reader

ALL OF THE NAMES OF people who have undergone neuroplastic transformations are real, except in the few places indicated, and in the cases of children and their families.

The Notes and References section at the end of the book includes comments on finer points in the chapters.

Preface

THIS BOOK IS about the discovery that the human brain has its own unique way of healing, and that when it is understood, many brain problems thought to be incurable or irreversible can be improved, often radically, and in a number of cases, as we shall see, cured. I will show how this process of healing grows out of the highly specialized attributes of the brain—attributes once thought to be so sophisticated that they came at a cost: that the brain, unlike other organs, could not repair itself or restore lost functions. This book will show that the reverse is true: the brain's sophistication provides a way for it to repair itself and to improve its functioning generally.

This book begins where my first book, *The Brain That Changes Itself*, ended. That book described the most important breakthrough in understanding the brain and its relationship to the mind since the beginning of modern science: the discovery that the brain is *neuroplastic*. Neuroplasticity is the property of the brain that enables it to change its own structure and functioning in response to activity and mental experience. That book also described many of the first scientists, doctors, and patients to make use of this discovery to bring about astonishing transformations in the brain. Until then, these transformations had been almost inconceivable, because for four hundred years, the mainstream view of the brain was that it could not change; scientists thought the brain was like a glorious machine, with parts, each of which performed a single mental function, in a single location in the brain. If a location was damaged—by a stroke or an injury or a disease—it could not be fixed because machines cannot repair themselves or grow new parts. Scientists also believed the circuits of the brain were unchangeable or "hardwired," meaning that people born with mental limitations or learning disorders were in all cases destined to remain so. As the machine metaphor evolved, scientists took to describing the brain as a computer and its structure as “hardware” and believed the only change that aging hardware undergoes is that it degenerates with use. A machine wears out: use it, *and* lose it. Thus, attempts by older people to preserve their brains from decline by using mental activity and exercise were seen as a waste of time.

The *neuroplasticians,* as I called the scientists who demonstrated that the brain is plastic, refuted the doctrine of the unchanging brain. Equipped, for the first time, with the tools to observe the *living* brain’s microscopic activities, they showed that it changes as it works. In 2000 the Nobel Prize in Physiology or Medicine was awarded for demonstrating that as learning occurs, the connections among nerve cells increase. The scientist behind that discovery, Eric Kandel, also showed that learning can “switch on” genes that change neural structure. Hundreds of studies went on to demonstrate that mental activity is not only the product of the brain but also a shaper of it. Neuroplasticity restored the mind to its rightful place in modern medicine and human life.

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THE INTELLECTUAL REVOLUTION DESCRIBED IN *The Brain That Changes Itself* was the beginning. Now, in this book, I tell of the astounding advances of a second generation of neuroplasticians who, because they did not have the burden of proving the existence of plasticity, have been liberated to devote themselves to understanding and using plasticity’s extraordinary power. I have traveled to five continents to meet with them—the scientists, clinicians, and their patients—in order to learn their stories. Some of these scientists work in the cutting-edge neuroscience labs of the Western world; others are clinicians who have applied that science; and still others are clinicians and patients who together stumbled upon neuroplasticity and perfected effective treatment techniques, even before plasticity had been demonstrated in the lab.

One patient after another in this book had been told they would never get better. For decades, the term *healing* was seldom used in connection with the brain, as it was with other organ systems, such as the skin or the bones or the digestive tract. While organs such as the skin, liver, and blood could repair themselves by replenishing their lost cells using stem cells to function as “replacement parts,” no such cells were found in the brain, despite decades of searching. Once neurons were lost, no evidence could be found that they were ever replaced. Scientists tried to find ways to explain this in evolutionary terms: in the course of evolving into an organ with millions of highly specialized circuits, the brain simply lost the ability to supply those circuits with replacement parts. Even if neuronal stem cells—baby neurons—were to be found, how, it was wondered, would they be of any help? How would they ever integrate into the sophisticated but dizzyingly complex circuits of the brain? Because it wasn’t thought possible to heal the brain, most treatments used medication to “prop up the failing system” and decrease symptoms by temporarily changing the chemical balance in the brain. But stop the medication, and the symptoms would return.

It turns out that the brain is not too sophisticated for its own good after all. This book will show that this very sophistication, which involves brain cells being able to constantly communicate electrically with one another, and to form and re-form new connections, moment by moment, is the source of a unique kind of healing. True, in the course of specializing, important reparative abilities, available to other organs, were lost. But others were gained, and they are mostly expressions of the brain’s plasticity.

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EACH OF THE STORIES IN this book will illustrate a different facet of these neuroplastic ways of healing. The more I immersed myself in these different kinds of healing, the more I began to make distinctions among them and to see that some of the approaches targeted different stages of the healing process. I have proposed (in Chapter 3) a first model of the stages of neuroplastic healing, to help the reader see how they all fit together.

Just as the discoveries of medication and surgery led to therapies to relieve a staggering number of conditions, so does the discovery of neuroplasticity. The reader will find cases, many very detailed, that may be relevant to someone who has, or cares for someone who has experienced, chronic pain, stroke, traumatic brain injury, brain damage, Parkinson's disease, multiple sclerosis, autism, attention deficit disorder, a learning disorder (including dyslexia), a sensory processing disorder, a developmental delay, a part of the brain missing, Down syndrome, or certain kinds of blindness, among others. In some of these conditions, complete cures occur in a majority of patients. In other cases, illnesses that are moderate to severe can sometimes become milder. I shall describe parents who were told that their autistic or brain-damaged children would never complete a normal education, but who saw them do so, graduate, even go to university, become independent, and develop deep friendships. In other situations, an underlying serious illness remains, but its most troubling symptoms are radically reduced. In still others, the risk of getting an illness such as Alzheimer's (in which the brain's plasticity decreases) is significantly reduced (discussed in Chapters 2 and 4), and ways of increasing plasticity are introduced.

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MOST OF THE INTERVENTIONS IN this book make use of energy—including light, sound, vibration, electricity, and motion. These forms of energy provide natural, noninvasive avenues into the brain that pass through our senses and our bodies to awaken the brain's own healing capacities. Each of the senses translates one of the many forms of energy around us into the electrical signals that the brain uses to operate. I will show how it is possible to use these different forms of energy to modify the patterns of the brain's electrical signals and then its structure.

In my travels, I saw examples of sounds played into the ear, to treat autism successfully; vibration on the back of the head, to cure attention deficit disorder; gentle electrical stimulators tingling on the tongue, to reverse symptoms of multiple sclerosis and heal stroke; light shone onto the back of the neck to treat brain injury, into the nose to help sleep, or administered intravenously to save a life; and the slow, soft movements of the human hand over the body to cure a girl, born missing a huge section of her brain, of cognitive problems and near paralysis. I will show how all these techniques stimulate and reawaken dormant brain circuits. Among the most effective ways to do so is by using thought itself to stimulate brain circuits, which is why most of the interventions I witnessed paired mental awareness and activity with the use of energy.

The use of energy and the mind together to heal, while novel in the West, has of course been central to traditional Eastern medicine. Only now are scientists beginning to glimpse how these traditional practices may work in terms of Western models, and it is remarkable the extent to which almost all the neuroplasticians I visited were deepening their understanding of how to use neuroplasticity by linking insights from Western neuroscience to insights from Eastern health practices, including traditional Chinese medicine, ancient Buddhist meditation and visualization, martial arts such as tai chi and judo, yoga, and energy medicine. Western medicine has long dismissed Eastern medicine—practiced by billions of people for millennia—and its claims, often because it seemed too far-fetched to accept that the mind can alter the brain. This book will show how neuroplasticity provides a bridge between humanity's two great but hitherto estranged medical traditions.

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IT MAY SEEM ODD THAT the ways of healing described in this book so frequently use the body and the senses as primary avenues to pass energy and information into the brain. But these are the avenues the brain uses to connect with the world, and so they provide the most natural and least invasive way to engage it.

One reason clinicians have overlooked using the body to treat the brain is the recent tendency to see the brain as more complex than the body and as the essence of who we are. In this common view, “We are our brains,” the brain is the master controller, and the body is its subject, there to follow the master’s orders.

This view was accepted because 150 years ago neurologists and neuroscientists, in one of their greatest accomplishments, began to demonstrate the ways in which the brain can control the body. They learned that if a stroke patient couldn’t move his foot, the problem wasn’t in his foot, as he felt it to be, but in the brain area that controlled the foot. Through the nineteenth and twentieth centuries, neuroscientists mapped where the body was represented in the brain. But the occupational hazard of brain mapping was to begin to believe that the brain was “where *all* the action is”; some neuroscientists began to talk about the brain almost as though it were disembodied, or as though the body were a mere appendage to it, mere infrastructure to support the brain.

But that view of an imperial brain is not accurate. Brains evolved many millions of years *after* bodies did, to support bodies. Once bodies had brains, they changed, so body and brain could interact and adapt to each other. Not only does the brain send signals to the body to influence it; the body sends signals to the brain to affect it as well, and thus there is constant, two-way communication between them. The body abounds with neurons, the gut alone having 100 million. Only in anatomy textbooks is the brain isolated from the body and confined to the head. In terms of the way it functions, the brain is always linked to the body and, through the senses, to the world outside. Neuroplasticians have learned to use these avenues from the body to the brain to facilitate healing. Thus, while a person who has had a stroke may not be able to use his foot because the brain is damaged, moving the foot can, at times, awaken dormant circuits in the injured brain. The body and mind become partners in the healing of the brain, and because these approaches are so noninvasive, side effects are exceedingly rare.

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IF THE IDEA OF POWERFUL and yet noninvasive treatments for brain problems seems too good to be true, it is for historical reasons. Modern medicine began with modern science, which was conceived as a technique for the conquest of nature, for—as one of its founders, Francis Bacon, put it—“the relief of man’s estate.” This idea of conquest gave rise to the many military metaphors that are used in everyday medical practice, as Abraham Fuks, a former dean of medicine at McGill University, shows. Medicine became a “battle” against disease. Drugs are “magic bullets”; medicine fights “the war against cancer” and “combats AIDS,” with “doctor’s orders,” from the “therapeutic armamentarium.” This “armamentarium,” as physicians call their bag of therapeutic tricks, honors invasive high-tech treatments as more scientifically serious than noninvasive ones. There is definitely a time for a martial attitude in medicine, especially in emergency medicine: if a blood vessel in the brain bursts, the patient needs invasive surgery and a neurosurgeon, with nerves of steel, to operate. But the metaphor creates problems too, and the very idea that it is possible to “conquer” nature is a fond, naïve hope.

In this metaphor, the patient’s body is less an ally than the battlefield, and the patient is rendered passive, a helpless bystander, as he watches the confrontation that will determine his fate between the two great antagonists, the doctor and the disease. The attitude has even come to influence the ways many physicians now talk to their patients, interrupting their story as they speak, because often the high-tech physician is less interested in their narrative than in their lab test.

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NEUROPLASTIC APPROACHES, ON THE OTHER hand, require the active involvement of the whole patient in his or her own care: mind, brain, and body. Such an approach recalls the heritage not only of the

East but of Western medicine itself. The father of scientific medicine, Hippocrates, saw the body as the major healer, and the physician and patient working together *with* nature, to help the body activate its own healing capacities.

In this approach, the health professional not only focuses on the patient's deficits, important as they may be, but also searches for healthy brain areas that may be dormant, and for existing capacities that may aid recovery. This focus doesn't advocate naïvely replacing the neurological nihilism of the past with an equally extreme neurological utopianism—replacing false pessimism with false hope. To be valuable, discoveries of new ways of healing the brain do not have to guarantee that all patients can be helped all the time. And often, we simply don't know what will happen, until the person, with the guidance of a knowledgeable health professional, gives the new approaches a try.

The word *heal* comes from the Old English *haelan* and means not simply "to cure" but "to make whole." The concept is very far from the idea of "cure" in the military metaphor, with its associated ideas of divide and conquer.

What follow are stories of people who have transformed their brains, recovered lost parts of themselves, or discovered capacities within that they never knew they had. But the true marvel is less the techniques than the way that, through millions of years, the brain has evolved, with sophisticated neuroplastic abilities and a mind that can direct its own unique restorative process of growth.

Chapter 1

Physician Hurt, Then Heal Thyself

Michael Moskowitz Discovers That Chronic Pain Can Be Unlearned

MICHAEL MOSKOWITZ, M.D., is a psychiatrist-turned-pain-specialist who has often been forced to use himself as a guinea pig.

Burly, buoyant, and six feet tall, Moskowitz looks a decade younger than his sixty-odd years. He wears oval John Lennon glasses; has slightly long, graying curls of hair, a mustache, and a beatnik's soul patch beneath his lower lip. He smiles a lot. I first saw Moskowitz in Hawaii, where he was moderating a serious and sober panel at the American Academy of Pain Medicine. He was in a suit, but he seemed too big a personality, too boyish, to be wearing one. A few hours later, on the beach, he wore shorts and wild colors and was unconstrained, joking, bringing out the boyishness in me. We somehow got into a conversation about how physicians—so often interested in diagnostic categories, which are supposed to be like ideal forms, unvarying from person to person—can easily forget how different people really are. "Like me, for instance," he said.

"How so?" I asked.

"My anatomy." Whereupon he pulled off his Hawaiian shirt to proudly display that his chest bore not two but three male nipples.

"A true freak of nature," I joked. "Does it do you any good?"

Like the medical students we once were, we plunged into a juvenile, jocular debate: because nipples on the male are useless, which of us was more useless, the one with two or the one with three? Thus we got acquainted, and everything about him—his love of singing and playing the guitar, his hugely engaging manner and youthful voice—suggested that he was still very much a creature of the happy-go-lucky world of love, music, and easygoing, carefree abandon of the 1960s in which he came of age.

Not so.

Moskowitz spends most of his time immersed in the chronic pain of others. Their agony is unknown to most people, in part because they are often so drained by their pain that they stop wasting what little energy they have to express distress to those who can't help them. Chronic pain may be invisible on a patient's face, or it can give its victim a drawn, ghostly presence, because it sucks the life out of a person. Moskowitz, on the other hand, gets to share in its full burden. He and another psychiatrist-turned-pain-specialist, his long-standing southern friend Robert "Bobby" Hines, M.D., set up a pain clinic, Bay Area Medical Associates, in Sausalito, California, which treats West Coast patients with "intractable pain": those who have tried all other treatments, including all known drugs, "nerve blocks" (regular anesthetic injections), and acupuncture. The patients who end up there failed to recover in all known mainstream and alternative treatments and have usually been told, "Everything that can be done for you has been done."

"We are the end of the line," Moskowitz says. "We are where people come to die with their pain."

Moskowitz came to pain medicine after working for years as a psychiatrist. He has all the professional and scholarly credentials: he was on the examination council for the American Board of Pain Medicine (setting the exams for doctors in pain medicine); he is a former chairman of the education committee of the American Academy of Pain Medicine; and he has an advanced psychiatric fellowship in psychosomatic medicine. But Moskowitz became a world leader in the use of neuroplasticity for treating pain only after making some discoveries while treating himself.

A Lesson in Pain—The Kill Switch

On June 26, 1999, when he was forty-nine, Moskowitz and a friend snuck into the local San Rafael dump because he had heard that army tanks and other armored vehicles were being stored there for the Fourth of July parade. He couldn't resist the boyish pleasure of climbing up onto a tank turret. When he jumped off, a metal prong for holding gas cans on the tank's side caught his corduroys. As he fell, one leg shot up five feet, and he heard three popping sounds: his femur, the longest bone in the body, was cracking. When he looked down at his leg, he saw it was pointed way to the left, at a ninety-degree angle to the other leg. "I was a bit too old to be on tanks and a jeep. When I spoke afterward to a friend who was a personal injury lawyer, he said, 'You would have a great case if you were seven.'"

As a pain physician, he used the situation to observe a phenomenon that he had taught his students about but had never experienced; it would become central to his neuroplastic research. Immediately after he fell, his pain was a true 10 out of 10—that is, 10/10, as pain physicians measure it. Pain is rated from 0/10 to 10/10 (10 is being dropped into boiling oil). He had never known whether he himself would be able to stand a true 10. He realized he could.

"The first thing I thought was: how will I get to work Monday?" he told me. "The second thing I realized, while lying motionless on the ground waiting for the ambulance, was that once I stopped moving, I had literally no pain at all. I thought, 'Wow, this really does work! My brain simply shut off the pain—something I had been teaching my students for years. I had a firsthand experience that the brain, all on its own, can eliminate pain, just as I, a conventional pain specialist, had tried to do for patients by using drugs, injections, and electrical stimulation. As long as I didn't move, the pain was zero within about a minute.

"When the ambulance came, they gave me six milligrams of IV morphine. I said, 'Give me another eight.' They said, 'We can't,' and I said, 'I'm a pain doctor,' so they did, but when they moved me it was ten out of ten."

The brain can shut pain off because the actual function of acute pain is not to torment us but to alert us to danger. True, the word *pain* comes from the ancient Greek *poine,* which means "penalty," via the Latin *poena*, which means "punishment," but biologically, pain is not punishment for punishment's sake. The pain system is the hurt body's implacable advocate, a reward and penalty signaling system. It penalizes us when we are about to do something that *might* further damage our already injured body, and it rewards us with relief when we stop.

As long as Moskowitz didn't move, he was in no danger, so far as his brain could tell. He also knew that the "pain" was never really in the leg itself. "All my leg did was send signals to my brain. We know from general anesthesia, which puts the higher parts of the brain to sleep, that if the brain doesn't process these signals, there is no pain." But general anesthesia has to render us unconscious to eliminate pain; here he was, lying in agony on the ground, and in one moment, his completely *conscious* brain turned all his pain off. If only he could learn how to flip that switch for his patients!

But it wasn't just movement that posed a danger for Moskowitz. While waiting for the ambulance, he nearly died, because he bled about half of his entire blood volume into his leg, so it ballooned to twice the normal size: "my leg was the size of my waist." With all his blood pooling in his leg for hours, it was a miracle he didn't die from insufficient blood supply to his vital organs. But he made it to the hospital, where "the surgeon put the largest plate they had into my leg and said that if they had needed one more screw, they would have had to amputate."

During the surgery he almost died two more times. First he threw off an embolus—a blood clot—that could have lodged in his lungs or brain. Then the catheter implanted to drain his urine pierced his prostate, and he spiked a high fever and went into septic shock—a life-threatening condition in which the body is overwhelmed by infection. His blood pressure fell to 80/40.

Yet he survived—and learned another pain lesson: the wise use of sufficient morphine during his acute pain prevented his nerves from being chronically stimulated and saved him from developing a chronic pain syndrome. (This was the reason he requested more morphine when his acute pain was not covered.) Despite the severity of the accident, as the years have passed, he has had very little pain in the leg, and he can walk, about a mile and a half, as we did along the beach in Hawaii, without experiencing pain.

The fact that the brain has the ability to turn pain off so suddenly goes against our "commonsense" experience that pain comes from the body. The traditional scientific view of pain, as formulated by the French philosopher René Descartes four hundred years ago, was that when we are hurt, our pain nerves send a one-way signal up to the brain, and the intensity of the pain is proportional to the seriousness of our injury. In other words, pain files an accurate damage report about the extent of the body's injury, and that the role of the brain is to simply accept that report.

But that view was overturned in 1965, when the neuroscientists Ronald Melzack (a Canadian who studied phantom limbs and pain) and Patrick Wall (an Englishman who studied pain and plasticity) published the most important article in the history of pain, "Pain Mechanisms: A New Theory." Wall and Melzack argued that the pain perception system is spread throughout the brain and spinal cord, and that the brain, far from being a passive recipient, controls how much pain we feel. Their "gate control theory of pain" proposed that when pain messages are sent from damaged tissue through the nervous system, they must pass through several controls, or "gates," starting in the spinal cord, before they get to the brain. These messages ascend to the brain only if the brain gives them "permission" to do so, after determining whether they are important enough to be let through. (When President Reagan was shot through the chest in 1981, he initially just stood there, and neither he nor his Secret Service men knew he had been shot. As he later joked, “I had never been shot before, except in the movies. Then you always act as though it hurts. Now I know that does not always happen.”) If “permission is granted” for the signal to proceed to the brain, a gate will open and increase our feeling of pain by allowing certain neurons to turn on and transmit their signals. But the brain can also close a gate and block the pain signal by releasing endorphins, the narcotics made by our bodies to quell pain.

Before his accident, Moskowitz taught the latest versions of the gate theory to his residents, and that switches control the gates. But knowing such switches exist is one thing; knowing how to turn them off when you are lying in agony is another.

Another Lesson in Pain—Chronic Pain Is Plasticity Gone Wild

Moskowitz’s tank accident wasn’t the first time he developed important insights about pain by having it himself. Several years earlier a pain in the neck, caused by a water-skiing accident, taught him another lesson, one that helped him understand the role of neuroplasticity in pain. In 1994, while water-skiing with his daughters, big-kid Moskowitz was speeding, splashing, and pounding at forty miles an hour in an inflated inner tube, when he flipped over and hit the water with his head bent backward. The resulting pain persisted. It was often an 8/10, on many days making it impossible for him to work. It soon dominated his life as no pain ever had. Morphine and other heavy-duty painkillers, and all the known treatments—physical therapy, traction (stretching the neck), massage, self-hypnosis, heat, ice, rest, anti-inflammatory drugs—barely touched it. That pain haunted and tormented him for thirteen years, becoming more severe as time passed.

He was fifty-seven when he hit rock bottom with his neck pain and began researching the discovery that the brain was neuroplastic and relating it to pain. The idea that chronic pain was caused by a neuroplastic event of the brain had been proposed by the German physiologist Manfred Zimmermann in 1978, but as neuroplasticity would remain generally unaccepted for another twenty-five years, Zimmermann’s idea was hardly known, and its applications to treat pain unexplored.

Acute pain alerts us to injury or disease by sending a signal to the brain, saying “This is where you are hurt—attend to it.” But sometimes an injury affects both our bodily tissues and the neurons in our pain system, including those in the brain and spinal cord, resulting in *neuropathic pain* (sometimes called *central pain* because the brain and spinal cord together make up our central nervous system).

Neuropathic pain occurs because of the behavior of neurons that make up our brain maps for pain. The external areas of our body are represented in our brain, in specific processing areas, called brain maps. Touch a part of the body’s surface, and a specific part of the brain map, devoted to that spot, will start to fire. These maps for the body’s surface are organized topographically, meaning that areas that are adjacent on the body are generally adjacent on the map. When the neurons in our pain maps get damaged, they fire incessant false alarms, making us believe the problem is in our body when it is mostly in our brain. Long after the body has healed, the pain system is still firing. The acute pain has developed an afterlife: it becomes *chronic pain*.

To understand how chronic pain develops, it’s helpful to know about the structure of neurons. Each neuron has three parts: the dendrites, the cell body, and the axon. The dendrites are treelike branches that receive input from other neurons. The dendrites lead into the cell body, which sustains the life of the cell and contains its DNA. Finally, the axon is a living cable of varying lengths (from microscopic ones in the brain to others that run down to the legs and can be three feet long). Axons are often compared to wires because they carry electrical impulses at very high speeds (from 2 to 200 miles per hour) toward the dendrites of neighboring neurons. A neuron can receive two kinds of signals: ones that excite it (excitatory signals) and ones that inhibit it (inhibitory signals). When a neuron receives enough excitatory signals, it will fire off its own signal. When it receives enough inhibitory signals, it becomes less likely to fire.

Axons don't quite touch the neighboring dendrites. They are separated by a microscopic space called a *synapse*. Once an electrical signal gets to the end of the axon, it triggers the release of a chemical messenger, called a *neurotransmitter,* into the synapse. The chemical messenger floats over to the dendrite of the adjacent neuron, exciting or inhibiting it. When we say that neurons "rewire" themselves, we mean that alterations occur at the synapse, strengthening and increasing, or weakening and decreasing, the number of connections between the neurons.

One of the core laws of neuroplasticity is that neurons that fire together wire together, meaning that repeated mental experience leads to structural changes in the brain neurons that process that experience, making the synaptic connections between those neurons stronger.* In practical terms, when a person learns something new, different groups of neurons get wired together. As a child learns the alphabet, the visual shape of the letter A is connected with the sound "ay." Each time the child looks at the letter and repeats the sound, the neurons involved "fire together" at the same time, and then "wire together"; the synaptic connections between them are strengthened. Whenever any activity that links neurons is repeated, those neurons fire faster, stronger, sharper signals together, and the circuit gets more efficient and better at helping to perform the skill.

The converse is also true. When a person stops performing an activity for an extended period, those connections are weakened, and over time many are lost. This is an example of a more general principle of plasticity: that it is a use-it-or-lose-it phenomenon. Thousands of experiments have now demonstrated this fact. Often the neurons that were involved in the skill will be taken over and used for other mental tasks that are now being performed more regularly. Sometimes one can manipulate the use-it-or-lose-it principle to undo brain connections that are not helpful, because neurons that fire apart wire apart. Suppose a person has formed a bad habit of eating whenever he is emotionally upset, associating the pleasure of food with the dulling of emotional pain; breaking the habit will require learning to disassociate the two. He might have to actively forbid himself from going to the kitchen when he is emotionally upset, until he finds a better way to handle his emotions.

Plasticity can be a blessing when the ongoing sensory input we receive is pleasurable, for it allows us to develop a brain that is better able to perceive and to savor pleasant sensations; but that same plasticity can be a curse when the sensory system that is receiving ongoing input is the pain system. That can happen when a person slips a disc, which then presses repeatedly on a nerve root in her spine. Her pain map for the area becomes hypersensitive, and she begins to feel pain not only when the disc hits the nerve when she moves the wrong way, but even when the disc is not pressing hard. The pain signal reverberates throughout her brain, so that pain persists even after its original stimulus has stopped. (Something similar, and even more drastic, happens in phantom limb pain, when a person who has lost a limb feels it is still attached and hurting. This more complex phenomenon is discussed in *The Brain That Changes Itself.*)

Wall and Melzack showed how a chronic injury not only makes the cells in the pain system fire more easily but can also cause our pain maps to enlarge their "receptive field" (the area of the body's surface that they map for), so that we begin to feel pain over a larger area of our body's surface. This was happening to Moskowitz, whose neck pain was spreading to both sides of his neck.

Wall and Melzack also showed that as maps enlarge, pain signals in one map can "spill" into adjacent pain maps. Then we may develop *referred pain,* when we are hurt in one body part but feel the pain in another, some distance away. Ultimately, the brain maps for pain begin to fire so easily that the person ends up in excruciating, unremitting pain, felt over a large area of the body—all in response to the smallest stimulation of a nerve.

Thus, the more often Moskowitz felt twinges of neck pain, the more easily his brain's neurons recognized it, and the more intense it got. The name for this well-documented neuroplastic process is *wind-up pain,* because the more the receptors in the pain system fire, the more sensitive they become.

Moskowitz realized that he was developing a chronic pain syndrome and was caught in a vicious cycle, a brain trap: each time he had an attack of pain, his plastic brain got more sensitive to it, making it worse, setting him up for a new, still worse attack next time. The intensity of his pain signal, the length of time it lasted, and the amount of space in the body it "occupied" all increased.

It was a case of plasticity gone wild.

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IN 1999 MOSKOWITZ BEGAN DRAWING pictures on his computer, demonstrating how chronic pain caused an expansion of the brain's pain maps. At the time, the specialty of pain medicine was often far more focused on how pain is processed in the spinal cord and the body's peripheral nervous system than in the brain. As late as 2006, the major text on pain, *Wall and Melzack's Textbook of Pain,* had a chapter on plasticity and the spinal cord but none on plasticity and the brain. A few years later, in his article titled "Central Influences on Pain," Moskowitz began shifting that emphasis.

Moskowitz defined chronic pain as "learned pain." Chronic pain not only indicates illness; it is itself an illness. The body's alarm system is stuck in the "on" position, because the person has been unable to remedy the cause of an acute pain, and the central nervous system has become damaged. "Once chronicity sets in, the pain is much more difficult to treat."

Moskowitz's thinking was beginning to converge with another Melzack theory, called the neuromatrix theory of pain. Acute pain is a sensation we feel, an "input" that comes into the brain from the bottom up, from our sense receptors. But chronic pain is more complex and more a top-down process. The essence of the neuromatrix theory of pain is that chronic pain is more a perception than a raw sensation, because the brain takes many factors into account to determine the extent of danger to the tissues. Scores of studies have shown that along with assessing damage, the brain, when developing our subjective experience of pain perception, also assesses whether action can be taken to diminish the pain, and it develops expectations as to whether this damage will improve or get worse. The sum total of these assessments determines our expectation as to our future, and these expectations play a major role in the level of pain we will feel. Because the brain can so influence our perception of chronic pain, Melzack conceptualized it as more of "an output of the central nervous system."

Thus, the pain circuit is not a one-way circuit from body to brain; it constantly recycles signals, from the body to the brain and back. The full pain response doesn't stop once the pain signal enters the brain. It begins myriad automatic responses that evolved to avoid further damage and promote healing. We recoil; we guard our damaged limbs so they won't be moved; we groan and cry out for help; we assess and reassess the severity of our wound, if we can; and as studies show, we ride a roller coaster of ups and downs in our distress, based on our latest assessment. If a person develops chest pain behind his breastbone that radiates down the left arm, and thinks these are symptoms of a heart attack, he will experience that pain as more intense than he will if his physician assures him that it's caused by a muscle strain.

"The brain," Moskowitz wrote (using the military metaphor), "mounts a counteroffensive against the incoming activity in an attempt to turn the excessive activity down." He detailed all the pain-modulating pathways that could do so—from the highest ones that originate in the brain's cerebral cortex (where reasoning occurs) to the "lower" input areas in the spinal cord.

A Neuroplastic Competition

Wishing to take charge of his own pain, in 2007 Moskowitz read fifteen thousand pages of neuroscience. He wanted to better understand the laws of neuroplastic change and put them into practice. He learned that not only can one strengthen circuits between brain areas by getting these areas to fire at the same time, but that one can weaken connections because "neurons that fire apart wire apart."

Could he, by fiddling with the timing of input to his brain, start to weaken links that had formed in his pain maps?

He learned that in our use-it-or-lose-it brain there is an ongoing competition for cortical real estate, because the activities the brain performs regularly take up more and more space in the brain by "stealing" resources from other areas. He drew three pictures of the brain that summarized what he had learned. The first was a picture of the brain in acute pain, with sixteen areas showing activity. The second was of the brain in chronic pain, showing those same areas firing but expanded over a larger area of the brain, and the third picture was of the brain when it is not registering pain at all.

As he analyzed the areas that fire in chronic pain, he observed that many of those areas also process thoughts, sensations, images, memories, movements, emotions, and beliefs—when they are not processing pain. That observation explained why, when we are in pain, we can't concentrate or think well; why we have sensory problems and often can't tolerate certain sounds or light; why we can't move more gracefully; and why we can't control our emotions very well and become irritable and have emotional outbursts. The areas that regulate these activities have been hijacked to process the pain signal.

The neuroplastician Michael Merzenich showed the competitive nature of plasticity by first mapping a monkey's brain over time. *Mapping a brain* means finding where in the brain different mental functions occur. For instance, sensations coming from each of the fingers in our right hand are processed in the touch area in our left hemisphere, and each finger has a separate location in the map where its touch sensations are processed. The signals from the neurons that process these sensations can be detected by microelectrodes, pins inserted into individual neurons, or right beside them, to detect when they fire. These electrical signals are passed to an amplifier, then to an oscilloscope with a screen that allows scientists to both see and hear the neuron as it fires. By inserting a microelectrode into the brain's sensory map for the thumb, then touching the actual thumb, a scientist can see "thumb" neurons firing on the screen.

Merzenich mapped a monkey's entire hand map. He began by touching the monkey's first finger and seeing which brain area started to fire. Once he found its brain map and defined its borders, he went on to the next finger. He found five finger areas, side by side for each of the five digits.

Then he amputated the animal's third finger. After a number of months, he remapped the monkey's remaining fingers and found that the brain maps for the second finger and fourth finger had grown into the space he had originally mapped for the third. Because the map was no longer getting input from the third finger, and because the second and fourth fingers were doing more work now that the third was missing, they took over that map space. Here was a very clear demonstration that brain maps are dynamic, that there is competition for cortical real estate, and that brain resources are allocated according to the principle of use it or lose it.

Moskowitz's inspiration was simple: what if he could use competitive plasticity in his favor? What if, when his pain started—instead of allowing those areas to be pirated and "taken over" by pain processing—he "took them back" for their original main activities, by forcing himself to perform those activities, no matter how intense the pain was?

What if, when he was in pain, he could try to override the natural tendency to retreat, lie down, rest, stop thinking, and nurse himself? Moskowitz decided the brain needed a counterstimulation. He would force those brain areas to process anything-but-pain, to weaken his chronic pain circuits.

Years as a pain medicine specialist had fixed in his mind the key brain areas he was targeting. Each of them could process pain and do other mental functions, and he listed what each did other than process pain, so he would be prepared to do those things while he was in pain. For instance, a part of the brain called the somatosensory area (*soma* means “body”) processes much of the body’s sensory input, including pain, vibration, and touch. What if, while he felt pain, he was to flood himself with vibration and touch sensations? Might those sensations prevent the somatosensory areas from being able to process pain?

He drafted a list of brain areas he would target (Table 1).

Table 1. Major Brain Areas Where Pain Is Processed

Somatosensory 1 and 2 (the sensory maps for our body parts):

Pain; touch, temperature sense, pressure sense, position sense, vibration sense, sensation of movement

Prefrontal Area:

Pain; executive function, creativity, planning, empathy, action, emotional balance, intuition

Anterior Cingulate:

Pain; emotional self-control, sympathetic control, conflict detection, problem solving

Posterior Parietal Lobe:

Pain; sensory, visual, auditory perception; mirror neurons (neurons that fire when we see other people move), internal location of stimuli, location of external space

Supplementary Motor Area:

Pain; planned movement, mirror neurons

Amygdala:

Pain; emotion, emotional memory, emotional response, pleasure, sight, smell, emotional extremes

Insula:

Pain; quiets the amygdala (the brain area just above); temperature, itch, empathy, emotional self-awareness, sensual touch, connects emotion with bodily sensation, mirror neurons, disgust

Posterior Cingulate:

Pain; visuospatial cognition, autobiographical memory retrieval

Hippocampus:

Helps to store pain memories

Orbital Frontal Cortex:

Pain; evaluates whether something is pleasant vs. unpleasant, empathy, understanding, emotional attunement

Moskowitz knew that when a particular brain area is processing acute pain, only about 5 percent of the neurons in that area are dedicated to processing pain. In chronic pain, the constant firing and wiring lead to an increase, so that 15 to 25 percent of the neurons in the area are now dedicated to pain processing. So about 10 to 20 percent of neurons get pirated to process chronic pain. Those were what he would have to steal back.

In April 2007 he put this theory into practice. He decided that he would first use visual activity to overpower the pain. A huge part of the brain is devoted to visual processing, and it couldn't hurt to have it on his side in this competition. He knew of two brain areas that process visual information and pain, the posterior cingulate (which helps us to visually imagine where things are in space) and the posterior parietal lobe (which also processes visual input).

Each time he got an attack of pain, he immediately began visualizing. But what? He visualized the very brain maps he had drawn, to remind himself that the brain can really change, so he'd stay motivated. First he would visualize his picture of the brain in chronic pain—and observed how much the map in chronic pain had expanded neuroplastically. Then he would imagine the areas of firing shrinking, so that they looked like the brain when there was no pain. "I had to be relentless—even more relentless than the pain signal itself," he said. He greeted every twinge of pain with an image of his pain map shrinking, knowing that he was forcing his posterior cingulate and posterior parietal lobes to process a visual image.

In the first three weeks, he thought he noticed a very small decrease in pain, and he doggedly continued to apply the technique, telling himself to "disconnect the network, shrink the map." After a month he was getting the hang of it and applying the technique so conscientiously that he *never* let a pain spike occur without doing some visualization or other mental activity to oppose it.

It worked. By six weeks, the pain between his shoulders in his back and near his shoulder blades had completely disappeared, never to return. By four months, he was having his first totally pain-free periods throughout his neck. And within a year he was almost always pain free, his average pain 0/10. If he had a brief relapse (usually from his neck being in a weird position, after a long drive, or having the flu), he was able to get his pain down to 0 in a few minutes. His life was totally changed, after thirteen years of chronic pain. During those thirteen years, his average pain had been 5/10, but could range up as high as 8/10 even on medication, and even his best days were 3/10.

The disappearance of the pain reversed the original pattern of its expansion. After his injury, he had acute pain on the left side of his neck, exactly where the injury had occurred. As time passed and the pain became chronic, it had neuroplastically extended to the right side of his neck and down to his midback. Now, with the visualizations, he noticed that the borders of the pain on the right were the first to get smaller. Then the pain on the left side began to retract and went away.

After six weeks of results, he started to share his discovery with his patients.

His First Neuroplastic Patient

Jan Sandin was in her forties, a registered nurse on a cardiac ward at Sequoia Hospital in Redwood City, California. One day when she was working with a 280-pound woman patient, the patient accidentally gashed her own leg and became hysterical. Terrified that she would fall, she reached out her arms and grabbed Jan's neck, hanging on so tightly Jan couldn't breathe: "It felt like a death grip." The woman was screaming, too panicked to put her weight on her injured leg. Jan couldn't dislodge her, so she asked an assistant to maneuver the patient toward the bed and get ready to do a "one, two, three" lift. Jan heaved, but her assistant, in shock from the patient's screaming, didn't put her arms out to help. Suddenly Jan was supporting the full weight of nearly three hundred pounds. "I heard the sound of a rubber band snapping," she recalled, "and felt something inside me break." All five of her lumbar (low-back) discs were damaged, and the bottom one slipped and pressed against a nerve root. She developed sciatica pain down both legs and could not walk. Whenever she moved, her spine made a crunching sound.

In intense pain, Jan was taken to the emergency room. She was diagnosed as having damage to all the discs in her five lumbar vertebrae. After subsequent tests she was told she had so much degeneration of the spine, she would probably need to have those five vertebrae fused with surgery. Over the next few years she was given all the usual treatments for pain, including physiotherapy and heavy-duty opioid medications. Nothing helped, and the pain became chronic. Surgeons told her there was too much damage in her lower back to operate. After several brave attempts to return to work, she was declared disabled. She felt her life was over. "I was depressed and suicidal. And it didn't matter what drugs the doctors gave me—the pain never went away. I couldn't even watch TV or read because, on top of the pain, the drugs I took put me in a gray zone. There was no reason to live." She spent the next decade at home, never going out except to doctors' visits.

By the time she got to Moskowitz, she had been disabled with chronic pain for a decade. The slightest movement would trigger unbearable exacerbations. She spent entire days in her Jacuzzi, on huge doses of heavy-duty painkillers like morphine, which would lower her pain to a 5/10. Often she spent twelve hours a day in a Japanese massage chair but got little relief. Bent over with a cane, she could hardly get herself into Moskowitz's office.

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IT'S JULY 2009. THE WOMAN I see before me, Jan, is sixty-two years old, beaming, perky, relaxed, and off all medication. Moskowitz had been working conventionally with her for five years, using heavy-duty painkillers, when, in June 2007, he introduced her to the idea of training herself, using his neuroplastic technique. To motivate her for the neuroplastic challenge ahead—and she would have to counter the pain mentally *every* moment over the next weeks—he decided she would first have to understand plasticity and take inspiration from the successes of others who had been deemed incurable.

"One day, Moskowitz said, 'Okay, I have thought of something new,' and he gave me your book," Jan told me. "And I went right through it, so I could understand how the plasticity of the brain works. The book opened up a way for me to think I might be able to do something. I realized I was stuck in a fixed logic. Reading all the examples of different connections forming in the brain made me think something else might be possible."

Moskowitz showed her his three pictures of the brain and told her that she had to be more relentless than the pain in focusing on them. He asked her first to look at the pictures, then put them down and visualize them, while thinking about transforming her brain into the no-pain version. He urged her to hold on to the thought that if her brain looked like the no-pain picture, she couldn't have any pain.

"I started to take what you were saying in the book," she told me, "and what he was saying and put them into practice. He told me to look at the brain pictures seven times a day. But I sat in the massage chair and I looked at them *all day long,* because I had nothing else to do. I would visualize the pain centers firing, and then I thought about where my pain was coming from in my back. Then I would visualize how it went into the spine and then into my brain—but with no pain centers firing. In those first two weeks, I had moments when there was no pain. . . . It wasn't profound, because I felt, *Oh, it's not going to last.* Then I thought, *Oh, it's back again—don't get your hopes up.*

“By the third week I was starting to have a couple of minutes a day without chronic pain. It just stopped me in my tracks. And then it would come back. By the end of the third week, the time without pain seemed to increase. But it happened for such a short period of time that, honestly, I never really thought it would go away.

“By the fourth week, the pain-free periods were up to fifteen minutes to half an hour. I thought, *This is going to go away*.”

And it did.

Next, she started going off all her medications, terrified the pain would return, but it didn’t. “I wondered, *Is it a placebo?* But the pain still hasn’t come back. It has never come back.”

When I first saw Jan, she had been free of all medication and pain for a year and a half, and life was returning to normal. “It is like I was asleep for a decade. Now I want to stay up twenty-four hours a day and read, and catch up on all that I have missed. I want to be awake all the time.”

The MIRROR Acronym

Moskowitz began formulating acronyms, based on neuroplastic principles, to remind patients in chronic pain how to organize their minds (minds that were slightly foggy and disorganized by the pain) as they sought to undermine that pain. One was MIRROR, for Motivation, Intention, Relentlessness, Reliability, Opportunity, and Restoration.

Motivation is the first MIRROR principle. Most chronic pain patients go to their physicians with a passive attitude toward their pain. They have been trained that their role is to take a pill or submit to an injection. Generally they are so sapped by their pain, they assume this passive role easily, living from visit to visit, hoping the physician will find the magical medication to make life more bearable.

Now, in the Moskowitz approach, the patient must become active, must read about how pain develops, must actively visualize (or some equivalent) and take charge of her treatment. Motivation is especially difficult in the early weeks of Moskowitz’s technique, when the patient can’t be sure it is having any effect and finds that after the first small success, the pain returns. Patients tend to take these setbacks as a reason to feel helpless and hopeless and stop. The trick is to use each attack of pain as a motivator, an opportunity to apply the technique, which will ultimately work.

Intention is a subtle concept. The immediate intention is not to get rid of pain—it is to focus the mind, in order to change the brain. Thinking that the immediate reward will be pain reduction will make it hard to get there, because that reward comes slowly. In the early stages what counts is the mental effort to change. These mental efforts help build new circuits and weaken the pain networks. The initial reward, after an episode, is being able to say, “I got a pain attack and used it as an opportunity to exercise mental effort and develop new connections in my brain, which will help in the long run,” rather than “I got a pain attack, I tried to get rid of it, but am still in pain.” Moskowitz writes, in his patient handout: “If focus is merely on immediate pain control, positive results will be fleeting and frustrating. Immediate pain control is definitely part of the program, but the real reward is to disconnect excessively wired pain networks and to restore more balanced brain function in these pain processing regions of the brain.”

Relentlessness is the simplest concept of all. Pain intruding into consciousness is the signal to push back. What is challenging about relentlessness is that when the pain is just beginning to act up, the patient may think perhaps it will be enough to tolerate the pain or distract himself, hoping it will pass, or that it might be easier to pop a pill and nip it in the bud. But putting up with some pain, while trying to distract oneself with work, is not an intense enough focus to break the stranglehold of chronic pain. Research on neuroplasticity shows that intense focus is generally required to alter the circuits and make new connections. So casual distraction must be resisted, because it allows the pain to run unopposed. Thus, even if the pain seems mild, letting it go unopposed may mean it gets stronger next time. Relentlessness means: every time pain is detected, push back, with full focus, and with the specific intention of rewiring the brain back to what it was before the chronic pain began. No exceptions. No negotiations with pain.

Reliability is a reminder that the brain is not the enemy, and that the patient can rely upon it to restore and maintain normal function if it has clear and unrelenting directions to do so. For psychological reasons, when in pain, the sufferer feels penalized and tormented by it. But except in the case of certain neurotic psychological conflicts, which generally have to do with unconscious guilt, the brain and nervous system are not "trying to punish" the person in pain. The brain, like all living systems, constantly seeks a stable state. The problem is that at times, it stabilizes in a state of chronic pain. But if the brain is given a way to get back to its previous, pain-free state, before chronic pain set in, it will not generally oppose the change. After all, the pain system evolved to protect. It is an alarm system, not an enemy. "When unconscious systems are not enough to solve a brain/body problem," Moskowitz writes, "we have to bring in conscious control in the form of new learning until the brain and body can carry on without that conscious input. It is a fact that brain and body reliably turn conscious effort into unconscious action that allows us to move from learning to mastery, returning the disease of persistent pain to the fleeting symptom of acute pain."

Opportunity means turning each pain episode into a chance to repair the faulty alarm system. While it's hard to welcome an attack of pain, using it to rally oneself can feel constructive, knowing one is taking charge and is using the pain spike to heal. That attitude by itself can alter the mindset and brain chemistry. "Pain that persists," Moskowitz says, "is terrifying because it sets off the amygdala, before the parts of the brain that modify our emotional responses can be turned on.

"The result is that we reexperience the trauma that caused the pain and this trauma is continuously reinforced by it. The terror demoralizes us, and as pain-processing areas expand in the brain, we lose our full ability to problem-solve, regulate emotions, resolve conflicts, relate to others, distinguish other sensations from pain, effectively plan, and even remember how to apply our past experience to control pain. Every time the pain worsens, it feels like it is here to stay, and we must avoid it at all costs. The amygdala is not a place of moderation. It is a place of extreme emotions, fight-and-flight and post-traumatic stress disorder. Persistent pain demoralizes most people who have it. If, on the other hand, we turn the pain episodes into an opportunity to practice using our brains and bodies differently to gain control of the pain, then pain spiking shifts from an act of terror to a chance to soothe. . . . Essentially we are turning the disease of pain back to a symptom, a signal to rally us to do something to stop it."

Restoration means that the goal isn't to mask pain or take the edge off it, as medication or anesthetics would, but to restore normal brain function.

Once Moskowitz was able to put these six tools in his patients' hands, and motivate them toward the ambitious goal of completely normalizing their brain function, their attitude changed. Now when they had modest improvements, they felt not just temporary feelings of "relief" but a progressive increase in hope, which they then used to energize themselves, to continue applying the technique. A vicious cycle was turned into a virtuous one.

How Visualization Decreases Brain Pain

So far we have explained the cure that Moskowitz achieved as caused by competitive plasticity. For instance, a part of the brain, the posterior parietal lobe, normally processes both pain and visual perception. By visualizing constantly, Jan prevented that lobe from processing pain. Repeated visualization is a very direct way of using thought to stimulate neurons—neurostimulation. On brain scans, we can see signs of the blood rushing to the visual neurons of the brain that are being activated. What we have left out is that she and Moskowitz did a very *specific* form of visualization: they imagined that the area of the brain devoted to processing pain was shrinking.

I was intrigued by the use of visual imagery, which is not entirely new—hypnotists often use it to bring about pain relief, by asking patients to imagine that the area in pain is shrinking, or fading, or farther away. Put in neuroscientific terms, the hypnotists are actually getting their clients to experiment not with their physical bodies but with the subjective image they have of their bodies in their minds, what clinicians call the “body image.” The body image was first described in the 1930s by a psychiatrist and student of Freud, Paul Schilder, who pointed out that it is not identical to the physical body.

The body image is formed in the mind *and* is represented in the brain, then is unconsciously projected onto the body. Neuroscientists sometimes call it the “virtual body” to emphasize that it has an existence in the brain and mind that is *independent* of the physical body. This body image is built up with input from multiple brain maps including vision but also touch, pain, and proprioception (where our limbs and bodies are in space)—indeed, from any map that has information, sensory or even emotional, about our bodies. It is thus the sum total of all the different *inputs* to the brain from the different senses, but also includes the person’s own emotionally laden ideas about his or her body.

The body image can be quite in sync with the actual body, meaning it can be a fairly accurate representation of it. In those situations, we may even forget that our image of the body is a mental phenomenon that is different from the actual body. But when the body image doesn’t match the body, the difference is easy to detect. Many of us have experienced this mismatch without realizing it when the dentist gives a local anesthetic: suddenly the jaw and cheeks feel subjectively much larger than they really are. The mismatch is pronounced when someone with anorexia nervosa looks in the mirror and insists she is fat, when she is actually skin and bones, on the brink of starvation. She has the body image of a fat person, though her physical body is emaciated.

Around the time when Moskowitz was starting to use visualization, having chronic pain patients imagine that areas of their brain were shrinking, scientists in Australia were getting similar results by having patients in the lab “shrink” their body image to rewire their brains. In 2008 G. Lorimer Moseley, an Australian neuroscientist and one of the most creative pain researchers alive, with his colleagues, Timothy Parsons and Charles Spence, conducted an ingenious study of people with chronic hand pain and swelling. He asked them to observe their hands in different conditions. First, in the control situation, they looked at their hands while doing ten hand movements. Then they looked through binoculars without magnification (another control situation, just in case using binoculars had an influence on results) and moved their hands. Third, they watched their hands performing the movements through the binoculars at two times magnification. Finally, they looked through the wrong end of the binoculars, so that their hands looked smaller.

Intriguingly, the researchers found that the pain increased when the image of the hands was magnified, and decreased when it was miniaturized.

A skeptic might question the reliability of patients rating themselves. But these patients did have actual swelling in their hands, and when the researchers measured the circumference of the patients’ fingers during the experiment, they observed that the swelling increased when the patients were viewing their hands under magnification.

What this remarkable study shows, once again, is that the experience of pain is not wholly driven by sensory input from pain receptors but is influenced by the body image. When the brain, because of distorted visual input coming from the binoculars, determines that the pain is coming from a smaller area, it concludes, "Less damage." (Moseley proposes that the reason the pain is lessened is that the brain has "visuotactile cells" that simultaneously process both visual and tactile senses, and that magnifying the view of the area being touched increases input into these cells.)

Another breakthrough experiment in pain management involving visualization occurred by accident when academics from the University of Nottingham, England, went to a fair to demonstrate the use of an optical illusion called Mirage. The university's psychology department had developed Mirage in order to distort the body image, as part of a study of how the body map works.

At the fair, the researchers invited children to put their hands inside a box with a camera in it. Mirage then displayed distorted images of their hands on a large screen, where the children could see the distortions—a computerized version of a fun-house mirror.

Encouraged by the researchers, the children tugged gently on their fingers. When they did, on the screen it appeared as though their fingers were being stretched to three or four times their normal size. When they compressed their fingers, they would then appear to shrink on the screen. In other words, the image on the screen was altering their visual body image (leaving their physical body unchanged).

A grandmother of one of the children thought it looked fun and insisted on having a go. But she told the researchers they had better be gentle when they demonstrated the tugging on her hands, because she had arthritis in her fingers.

Dr. Catherine Preston explains, "We were giving her a practical demonstration of an illusory finger stretching when she announced, 'My finger doesn't hurt anymore' and asked whether she could take the machine home with her. We were just stunned—I don't know who was more surprised, her or us."

Preston followed up with a study of twenty volunteers with osteoarthritis, some of whom had constant pain in their hands, feet, and lower back. That study showed that using the device halved the level of pain in 85 percent of the volunteers. A number of people got the greatest pain reduction when the fingers were shrunk; others got most relief when their fingers were stretched; and some got pain reduction as long as the image of the finger was changed in any way. Many were able to use their fingers more easily while using the device.

It is not clear why "stretching" the imaged fingers would reduce pain; perhaps a stretched finger has different dimensions, and appears slimmer. What does seem clear is that real-time modification of the visual body image can lower the pain experience. It reminds us that the formation of the sense of the body in pain is dynamic—it is being remade all the time, depending on visual input. It shows that altering the visual imagery of the body can modify pain circuits. This is an important clue as to why Jan Sandin was able to look at imagery of her brain and imagine the pain signal shrinking: she said she strongly identified with those pictures of the brain in chronic pain and then imagined a transition to the picture of the brain out of pain—the signals shrinking away.

Jan hadn't simply been looking at brain pictures; she had also linked them to the pain she felt in her back. Ultimately, she formed a new body image map, which included the brain pictures, and was able to do so because our "master" brain map of our body image is a highly integrated combination of many different maps. It includes the primary biological ones, based on sensory input from our bodies, but also artificial ones, such as our reflection in a mirror, or a favorite photograph of ourselves, or even medical imagery, as when we get an echocardiogram and see our heart contracting, or we are shown an X-ray that displays our insides. Whatever can be defined as representing us can ultimately make its way into our master body image. (The ways the body image can be extended to include artificial images is discussed in detail in Chapter 7 of

The Brain That Changes Itself.)

Is It a Placebo?

"Is it the placebo effect?" I ask Moskowitz, echoing Jan's question after she got better unexpectedly, fearing it wouldn't last. It's not that I believe it is, but I know that this is the question skeptics will ask him.

The term *placebo* derives from the Latin "I shall please." The placebo effect occurs when a patient with symptoms is given a dummy pill, such as a sugar pill, or injections with no active ingredients, or pseudo-surgery* (when a physician opens a patient's body up but doesn't operate, just pretends to, then closes it). The patient is told she is getting effective treatment, and surprisingly, she often gets immediate relief and sometimes as much improvement as might occur with the "real" or "active" treatment. Placebos can be used to treat pain, depression, arthritis, irritable bowel, ulcers, and a wide range of illnesses. But it doesn't work for all illnesses—cancer, or viruses, or schizophrenia, for instance. Most physicians assume that whenever a patient gets better inexplicably, some powerful psychological factor is involved.

So I ask Moskowitz, "Is it the placebo effect?"

"I hope so," he laughs.

He laughs because he knows that if it is placebo, it wouldn't be nearly the problem most skeptics believe it to be. The latest brain scan research shows that when the placebo effect occurs in pain patients, or in patients with depression, the changes in the brain are *almost identical* to those that occur when they get better with medication. Clinicians and scientists who study mind-body medicine argue that if we could develop a way of systematically activating the brain circuitry that underlies the placebo effect, it would represent a huge medical breakthrough.

For pain, the placebo effect generally runs at 30 percent or higher, meaning that if a pain patient is given a sugar pill instead of real medication, or injections that consist only of salt water (saline) instead of anesthetic, at least 30 percent will report significant pain relief. Before the discovery of neuroplasticity, researchers tended to assume that patients who experienced the placebo effect were mostly psychologically unstable, flighty, immature, poor, or female (all of which has since been shown to be untrue). Brain scan studies demonstrate that when the placebo effect occurs, brain structure changes. Placebo cures are not "less real" than cures by medication. They are examples of neuroplasticity in action: mind changing brain structure.

One of the groups pioneering these studies was led by a researcher who had serious doubts. Tor Wager, a Columbia University neuroscientist, was raised as a Christian Scientist and as a boy was taught that all illnesses were products of the mind, requiring prayer not medication. When he developed a severe skin rash that would not disappear through prayer, his mother took him to a doctor, who treated him with medication, successfully. Wager became skeptical of the idea that the mind could heal, and of the placebo effect, which he began to study, expecting to find it was ineffective. He gave painful shocks to volunteers, then gave them a placebo cream that he told them would diminish the pain. To his surprise, his studies showed the placebo cream worked. He then used fMRI scans to study what was happening in their brains. When the subjects were given shocks and felt pain, some of the same brain areas that Moskowitz had seen activated by pain lit up. When Wager gave them the placebo, he found reduced activation in the same areas that Moskowitz told his patients could be modified through visualization.

Using PET scans of the brain, Wager has also shown that placebo treatment turns off pain by getting key brain areas to increase the production of endogenous opioids—the opiumlike substances that the brain produces to erase pain. He showed that the placebo response strengthened the brain's wiring in the opioid-producing areas of the brain's pain system. In other words, the mind can release an internal supply of the natural balm that the brain normally produces. And unlike the opioids in medications like morphine, these opioids are nonaddictive.

Why It Isn't Just Placebo

"I'm totally open to the idea that this is placebo and suggestion," says Moskowitz, "but I have done this a long time, thirty years, since 1981, and I have never seen placebo or suggestion stick this long. I have never seen the changes for pain based on hypnosis or suggestion last longer than a week or so."

Moskowitz's assertion that placebos generally don't last reflects the consensus based on numerous placebo studies. If a response is very rapid, it is more likely to be a placebo response, but the placebo responders were more likely to suffer a relapse, though some studies show the placebo effect can last for weeks.

However, the exact opposite pattern is seen in Moskowitz's patients using the MIRROR approach and competitive plasticity. His patients often have no response for weeks, then gradually have less and less pain; once they have rewired their brains, they generally have to do the intervention less and less. I have seen the same pattern in people who used neuroplastic techniques to rewire their brains to cure learning disorders and to improve after strokes and traumatic brain injury: the symptoms didn't disappear quickly. Moskowitz's patients' pattern of change is also consistent with what we see when the brain learns a new skill, like playing a musical instrument or learning a language. The time frame is typical of what I have seen in significant neuroplastic change: the change occurred over weeks (often six to eight weeks) and required daily mental practice. It's hard work.

A skeptic, who has difficulty imagining that visualizing a specific brain pain area can diminish pain, might argue that all Moskowitz is doing is finding a way to relax his patients and lower their general level of arousal, so that their pain bothers them less. But one thing that has been learned from studying the placebo effect is that the mind has the ability to target pain with laserlike precision.

The mind-brain-body healing process is *not* merely a general, nonspecific process that resets the entire nervous system, the way relaxation does. Mysteriously—because we don't yet know the mechanism—it targets only what the patient believes is the focus. With elegant simplicity, the researcher Guy Montgomery placed weights heavy enough to cause pain on both index fingers of his subjects. He then applied a placebo cream to only one index finger. He found that pain was relieved only in the finger that got the placebo cream. These people were not being relaxed or put in a trance: they were in normal states of conscious arousal, and still their minds could pinpoint the exact spot of acute pain and eliminate it.

What Moskowitz has added to our understanding of this ability of the mind to eliminate a particular pain is that constant mental practice is necessary to strengthen this ability and change the firing of the brain in a way that is sustained.

Unlike medication or placebo, the neuroplastic technique allows patients to reduce its use over time, once their networks have rewired. The effects last. Moskowitz has patients who have kept their gains for five years. Many of his relatively pain-free patients still have damage in their bodies, which can, on occasion, trigger acute pain. He thinks that once they have learned and practiced the technique over hundreds of hours, their unconscious mind takes over the task of blocking pain by using competitive plasticity. When it doesn't, they can still use the spike of pain as the signal to consciously use competitive plasticity to do more rewiring.

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ONE OF MOSKOWITZ'S MOST IMPORTANT insights is that the new opioid narcotics, so popular for pain treatment, have actually made pain problems worse, because neither the drug companies nor most physicians take into account the role of neuroplasticity in pain. Opioid narcotics, the most potent pain medications we have, generally don't work well over long periods of time. Often within days or weeks, patients become "tolerant" to such a drug: the size of the initial dose loses its effect, so they need ever more medication, or they experience "breakthrough pain" while on the drug. But as the dose is increased, so too is the danger of addiction and overdose. To better block pain, drug companies invented "long-acting" opioids, such as OxyContin, a long-acting morphine. People with chronic pain would often be placed on OxyContin-like drugs for life.

As we've seen, the brain makes its own opioidlike substances to block pain, and the manufactured drugs supplement them by attaching to the brain's own opioid receptors. As long as scientists believed that the brain couldn't change, they never anticipated that bombarding the opioid receptors with opioid medications could do harm. However, says Moskowitz, "once we saturate all our God-given receptors, the brain produces new ones." It adapts to being inundated by long-term opioids by becoming less sensitive to them—and thus patients become more sensitive to pain, and more dependent on their drugs, which can make their chronic pain worse. The problem exists, says Moskowitz, with all the pain medicines.

Once he made his discoveries, he slowly began to wean many patients from their long-term opioids. A key to success was to lower the dose very slowly, thereby giving the neuroplastic brain the time it needed to adapt to being without drugs, so the patient wouldn't experience any "breakthrough pain." Tapering slowly, down to 50 to 80 percent of the original dose, could break the cycle of opioid-induced pain sensitivity.

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"I DON'T BELIEVE IN PAIN management anymore," says Moskowitz. "I believe in trying to cure persistent pain."

He has helped patients with a whole range of chronic pain syndromes to diminish their pain, including those with chronic low-back pain from nerve injury and inflammatory damage, diabetic neuropathy, some cancer pain, abdominal pain, neck degeneration pain, amputation, trauma to the brain and spinal cord, pelvic floor pain, inflammatory bowel, irritable bowel, bladder pain, arthritis, lupus, trigeminal neuralgia, multiple sclerosis pain, post-infectious pain, nerve injuries, neuropathic pain, some central pain, phantom limb pain, degenerative disc disease in all regions of the spine, pain from failed back surgery, and pain from nerve root injury, among others. I met many of his patients who had either come off their medications or radically reduced them, so that they have far fewer side effects. Patients have had successes in all these pain syndromes, but only when they were able to do the relentless mental work required.

This burden of work is one of the limits of his approach. Not everyone is like Jan, willing to apply themselves relentlessly, especially in the early weeks, when nothing appears to be changing, even if they have a physician as inspiring as Michael Moskowitz. He's observed that when patients have not benefited, they have seemed unable, for whatever reason, to mobilize themselves mentally for the challenge. Many, perhaps most, need positive reinforcement.

Jan, Moskowitz, and others were restored by understanding how to use competitive plasticity. Pleasure returned. Many clinicians would, at that point, have focused the rest of their career on teaching visualization, because so many patients responded to it. But not all had responded, and that left Moskowitz dissatisfied. Perhaps some needed approaches other than visualization to compete with pain. Moskowitz wondered: in addition to helping his patients to slowly unwire their brain's pain circuitry, could he make use of the body's own pleasure chemistry to alleviate pain more rapidly? And what if the idea of truly restoring patients meant not only achieving the absence of pain but nothing less than bringing them back to a fuller life?

In studying these questions, he would be helped by Marla Golden, a physician who specializes in chronic pain, whom he met in 2008. Golden, an emergency physician, also trained in osteopathy, a hands-on practice. She has profoundly deepened Moskowitz's understanding of how to use touch, sound, and vibration, each in a unique way, to flood the brain and to competitively counter pain. (In Chapter 8 we shall see how sound, vibration, and touch can heal many kinds of serious brain problems.) She has achieved remarkable results by using her hands, approaching pain through the body.

"I had always thought the body was a bag for the brain," Moskowitz said to Golden when they met, on the assumption that what a patient feels in his body is the product of brain activity. But Golden was able to show Moskowitz that the body is as much an avenue into the brain as is the mind. "She's the yin to my yang," he says, and he has totally internalized her approach. Now, they collaborate and have pioneered a true brain-body approach to chronic pain, in which patients receive simultaneous neuroplastic input from the mind and body to influence the brain. Golden's hands are so sensitive, Moskowitz says, she sometimes seems to "see" with them, finding problem areas and rapid ways to ease chronic pain. I have seen Moskowitz and Golden work together, in demonstrations, on the same patient at once. Moskowitz talks to the patient, helping her to use her mind to alter brain circuits neuroplastically, while Golden works on the patient's body, stimulating touch and vibration sense at the same time. I have followed a number of their patients and seen remarkable progress.

As for Jan Sandin, who was cured in 2009, I returned to visit her in 2011. Her chronic pain syndrome had not returned, and she actually looked younger than she had in 2009. Today, in 2014, she continues to be pain free, knowing that her relentless application of her mind in those days—when she was confined to a chair, immobilized, depressed and suicidal from her pain—was the best investment of mental energy she ever made.

Chapter 2

A Man Walks Off His Parkinsonian Symptoms

How Exercise Helps Fend Off Degenerative Disorders and Can Defer Dementia

MY WALKING COMPANION, John Pepper, was diagnosed with Parkinson's disease, a movement disorder, over two decades ago. He first started getting symptoms nearly fifty years ago. But unless you are a perceptive and well-trained observer, you would never know it. Pepper moves too quickly for a Parkinson's patient. He doesn't appear to have the classic symptoms: no shuffling gait; no visible tremor when he pauses or when he moves; he does not appear especially rigid, and seems able to initiate new movements fairly quickly; he has a good sense of balance. He even swings his arms as he walks. He shows none of the slowed movements that are the hallmark of Parkinson's. He hasn't been on anti-Parkinson's medication for nine years, since he was sixty-eight years old, yet appears to walk perfectly normally.

In fact, when he gets going at his normal walking speed, I can't keep up with him. He's now going on seventy-seven and has had this illness, which is defined as an incurable, chronic, progressive neurodegenerative disorder, since his thirties. But instead of degenerating, John Pepper has been able to reverse the major symptoms, the ones that Parkinson's patients dread most, those that lead to immobility. He's done so with an exercise program he devised and with a special kind of concentration.

The beach we are on is called Boulders because of the huge, round rocks that ring it, lined up like adjacent marbles. It is just off the southernmost tip of Africa, where the Indian and Atlantic Oceans meet, and we have come to observe an African penguin colony. Slightly off the beaten path, we are in search of jackass penguins, so known because of their braying mating calls. We see our first penguin as it rockets out of the

Indian Ocean with optimistic grace. It’s called porpoising. But when the penguin comes ashore, he has an ungainly waddle.

We have been told that in the next little stretch of sand, which is surrounded by the huge ten-foot-tall boulders, we will find a group of penguins and their babies. But I don’t see how we will reach them through the wall of rock because the cracks between the boulders are so narrow and low. Still, Pepper urges me to go through one of the gaps. I manage to contort myself, crouching on my hands and knees, in a claustrophobic passage only a couple of feet high, crawling and twisting my spine under the low ceiling over the water-lapped sand, and barely get through. Then I look back. He follows.

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