## Three

# NOSE

"You look like shit," says Dr. Nayak.

It's early afternoon and I'm back at the Stanford Department of Otolaryngology Head and Neck Surgery Center. I'm splayed out on the examination chair while Nayak nudges an endoscope up my right nostril. The smooth desert dunes I journeyed through ten days ago look like they've been hit by a hurricane. I'll skip the details; let's just say my nasal cavity is a mess.

"Now your favorite part," says Nayak, chuckling. Before I sneeze or can consider running away, he grabs the wire brush and pushes it a few inches into my head. "It's pretty soupy in there," he says, sounding somewhat pleased. He repeats with the left nostril, places the gunk-covered RNA brushes into a test tube, then scoots me out of the way.

For the past week and a half I'd been waiting for this moment. I'd anticipated removing these plugs and tape and cotton to be a celebratory scene involving high-fives and nasal sighs of relief. I could breathe like a healthy human again!

In reality, it's minutes of discomfort followed by more obstruction. My nose is such a mess that Nayak has to grab a pair of pliers and insert several inches of cotton swabs into each nostril to keep whatever is up there from spilling onto the floor. Then it's back to the pulmonary function tests, an X-ray, the phlebotomist, and the rhinologist, repeating all the tests Olsson and I took before the obstruction phase. The results will be ready in a few weeks.

It's not until I get home that evening and rinse my sinuses several times that I can take a first full breath through my nose. I grab a coat and walk barefoot to the backyard. There are wispy plumes of cirrus clouds moving across the night sky, as big as spaceships. Above them, a few stubborn stars punch through the mist and cluster around a waxing moon.

I exhale stale air from my chest and take in a breath. I smell the sour, old-sock stink of mud. The black-label ChapStick of the damp doormat. A Lysol whiff of the lemon tree and the anise tinge of dying leaves.

Each of these scents, this material in the world, explodes in my head in a Technicolor burst. The scents are so sparkled and alarming that I can almost see them—a billion colored dots in a Seurat painting. As I take in another breath, I imagine all these molecules passing down my throat and into my lungs, pushing deeper into my bloodstream, where they provide fuel for thoughts and the sensations that made them.

Smell is life's oldest sense. Standing here alone, nostrils flaring, it occurs to me that breathing is so much more than just getting air into our bodies. It's the most intimate connection to our surroundings.



Everything you or I or any other breathing thing has ever put in its mouth, or in its nose, or soaked in through its skin, is hand-me-down space dust that's been around for 13.8 billion years. This wayward matter has been split apart by sunlight, spread throughout the universe, and come back together again. To breathe is to absorb ourselves in what surrounds us, to take in little bits of life, understand them, and give pieces of ourselves back out. Respiration is, at its core, reciprocation.

Respiration, I'm hoping, can also lead to restoration. Starting today, I will attempt to heal whatever damage has been done to my body over the past ten days of mouthbreathing and try to ensure ongoing health in the future. I'll put into practice several thousand years of teachings from several dozen pulmonauts, breaking down their methods and measuring the effects. Working with Olsson, I'll explore techniques to expand the lungs, develop the diaphragm, flood the body with oxygen, hack the autonomic nervous system, stimulate immune response, and reset chemoreceptors in the brain.

The first step is the recovery phase I've just done. To breathe through my nose, all day and all night.

The nose is crucial because it clears air, heats it, and moistens it for easier absorption. Most of us know this. But what so many people never consider is the nose's unexpected role in problems like erectile dysfunction. Or how it can trigger a cavalcade of hormones and chemicals that lower blood pressure and ease digestion. How it responds to the stages of a woman's menstrual cycle. How it regulates our heart rate, opens the vessels in our toes, and stores memories. How the density of your nasal hairs helps determine whether you'll suffer from asthma.

Few of us ever consider how the nostrils of every living person pulse to their own rhythm, opening and closing like a flower in response to our moods, mental states, and perhaps even the sun and the moon.

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Thirteen hundred years ago, an ancient Tantric text, the *Shiva Swarodaya*, described how one nostril will open to let breath in as the other will softly close throughout the day. Some days, the right nostril yawns awake to greet the sun; other days, the left awakens to the fullness of the moon. According to the text, these rhythms are the same throughout every month and they're shared by all humanity. It's a method our bodies use to stay balanced and grounded to the rhythms of the cosmos, and each other.

In 2004, an Indian surgeon named Dr. Ananda Balayogi Bhavanani attempted to scientifically test the *Shiva Swarodaya* patterns on an international group of subjects. Over the course of a month, he found that when the influence of the sun and moon on the Earth was at its strongest—during a full or new moon—the students consistently shared the *Shiva Swarodaya* pattern.

Bhavanani admitted the data were anecdotal and much more research would be needed to prove that all humans shared in this pattern. Still, scientists have known for more than a century that the nostrils *do* pulse to their own beat, that they do open and close like flowers throughout the day and night.

The phenomenon, called nasal cycles, was first described in 1895 by a German physician named Richard Kayser. He noticed that the tissue lining one nostril of his patients seemed to quickly congest and close while the other would mysteriously open. Then, after about 30 minutes to 4 hours, the nostrils switched, or "cycled." The shifting appeared to be influenced less by the moon's mysterious pull and more by sexual urges.

The interior of the nose, it turned out, is blanketed with erectile tissue, the same flesh that covers the penis, clitoris, and nipples. Noses get erections. Within seconds, they too can engorge with blood and become large and stiff. This happens because the nose is more intimately connected to the genitals than any other organ; when one gets aroused, the other responds. The mere thought of sex for some people causes such severe bouts of nasal erections that they'll have trouble breathing and will start to sneeze uncontrollably, an inconvenient condition called "honeymoon rhinitis." As sexual stimulation weakens and erectile tissue becomes flaccid, the nose will, too.



After Kayser's discovery, decades passed and nobody offered a good reason for why the human nose was lined with erectile tissue, or why the nostrils cycled. There were many theories: some believed this switching provoked the body to flip over from side to side while sleeping to prevent bedsores. (Breathing is easier through the nostril opposite the pillow.) Others thought the cycling helped protect the nose from respiratory infection and allergies, while still others argued that alternate airflow allows us to smell odors more efficiently.

What researchers eventually managed to confirm was that nasal erectile tissue mirrored states of health. It would become inflamed during sickness or other states of imbalance. If the nose became infected, the nasal cycle became more pronounced and switched back and forth quickly. The right and left nasal cavities also worked like an HVAC system, controlling temperature and blood pressure and feeding the brain chemicals to alter our moods, emotions, and sleep states.

The right nostril is a gas pedal. When you're inhaling primarily through this channel, circulation speeds up, your body gets hotter, and cortisol levels, blood pressure, and heart rate all increase. This happens because breathing through the right side of the nose activates the sympathetic nervous system, the "fight or flight" mechanism that puts the body in a more elevated state of alertness and readiness. Breathing through the right nostril will also feed more blood to the opposite hemisphere of the brain, specifically to the prefrontal cortex, which has been associated with logical decisions, language, and computing.

Inhaling through the left nostril has the opposite effect: it works as a kind of brake system to the right nostril's accelerator. The left nostril is more deeply connected to the parasympathetic nervous system, the rest-and-relax side that lowers temperature and blood pressure, cools the body, and reduces anxiety. Left-nostril breathing shifts blood flow to the opposite side of the prefrontal cortex, the right area that plays a role in creative thought, emotions, formation of mental abstractions, and negative emotions.

In 2015, researchers at the University of California, San Diego, recorded the breathing patterns of a schizophrenic woman over the course of three consecutive years and found that she had a "significantly greater" left-nostril dominance. This breathing habit, they hypothesized, was likely overstimulating the right-side "creative part" of her brain, and as a result prodding her imagination to run amok. Over several sessions, the researchers taught her to breathe through her opposite, "logical" nostril, and she experienced far fewer hallucinations.

Our bodies operate most efficiently in a state of balance, pivoting between action and relaxation, daydreaming and reasoned thought. This balance is influenced by the nasal cycle, and may even be controlled by it. It's a balance that can also be gamed.

There's a yoga practice dedicated to manipulating the body's functions with forced breathing through the nostrils. It's called *nadi shodhana*—in Sanskrit, *nadi* means "channel" and *shodhana* means "purification"—or, more commonly, alternate nostril breathing.

I've been conducting an informal study of alternate nostril breathing for the past several minutes.

It's the second day of the nasal breathing "Recovery" phase, and I'm sitting in my living room, my elbows on the cluttered dining room table, softly sucking air through my right nostril, pausing for five seconds, and then blowing it out.



There are dozens of alternate nostril breathing techniques. I've started with the most basic. It involves placing an index finger over the left nostril and then inhaling and exhaling only through the right. I did this two dozen times after each meal today, to heat up my body and aid my digestion. Before meals, and any other time I wanted to relax, I'd switch sides, repeating the same exercise with my left nostril open. To gain focus and balance the body and mind, I followed a technique called *surya bheda pranayama*, which involves taking one breath into the right nostril, then exhaling through the left for several rounds.

These exercises felt great. Sitting here after a few rounds, I sense an immediate and potent clarity and relaxation, even a floatiness. As advertised, I've been entirely free of any gastroesophageal reflux. I haven't registered the slightest stomach ache. Alternate nostril breathing appeared to have delivered these benefits, but these techniques, I'd found, were usually fleeting, lasting only 30 minutes or so.

The real transformation in my body over the last 24 hours came from another practice: letting my nasal erectile tissues flex of their own accord, naturally adjusting the flow of air to suit the needs of my body and brain. It happened because of simply breathing through my nose.

As I'm quietly contemplating all this, Olsson comes barging in. "Good afternoon!" he yells. He's wearing his shorts and Abercrombie sweatshirt, and he plops down across from me while placing a blood-pressure cuff around his right arm. This is the same position he's assumed for the last eleven days straight, in pretty much the same clothes. Today, however, there's no bandage, nose clip, or silicone plugs up his nose. He's also breathing freely through his nostrils, taking in easy and silent inhales and exhales. His face is flushed, he's sitting upright, and he's so keyed up with energy that he can't stay still.

I figured that some of our new, bright outlook on life was psychosomatic until a few minutes later, when we checked our measurements. My systolic blood pressure had dropped from 142 ten days ago—a deep state of stage 2 hypertension—to 124, still a bit high but just a few points from a healthy range. My heart rate variability increased by more than 150 percent, and my carbon dioxide levels rose around 30 percent, taking me from a state of hypocapnia, which can cause dizziness, numbness in the fingers, and mental confusion, and placing me squarely within the medically normal zone. Olsson showed similar improvements.

And there's potential for much more. Because pulsing nasal cycles are only a small part of the nose's vital functions.

Imagine for a moment that you're holding a billiard ball at eye level a few inches from your face. Then imagine slowly pushing that entire ball inside the center of your face. The volume the ball would take up, some six cubic inches, is equivalent to the total space of all the cavities and passageways that make up the interior of the adult nose.

In a single breath, more molecules of air will pass through your nose than all the grains of sand on all the world's beaches—trillions and trillions of them. These little bits of air come from a few feet or several yards away. As they make their way toward you, they'll twist and spool like the stars in a van Gogh sky, and they'll keep twisting and spooling and scrolling as they pass into you, traveling at a clip of about five miles per hour.

What directs this rambling path are turbinates, six maze-like bones (three on each side) that begin at the opening of your nostrils and end just below your eyes. The turbinates are coiled in such a way that if you split them apart, they'd look like a seashell, which is how they got their other name, *nasal concha*, after the conch shell. Crustaceans use their elaborately designed shells to filter impurities and keep invaders out. So do we.

The lower turbinates at the opening of the nostrils are covered in that pulsing erectile tissue, itself covered in mucous membrane, a nappy sheen of cells that moistens and warms breath to your body temperature while simultaneously filtering out particles and pollutants. All these invaders



could cause infection and irritation if they got into the lungs; the mucus is the body's "first line of defense." It's constantly on the move, sweeping along at a rate of about half an inch every minute, more than 60 feet per day. Like a giant conveyor belt, it collects inhaled debris in the nose, then moves all the junk down the throat and into the stomach, where it's sterilized by stomach acid, delivered to the intestines, and sent out of your body.

This conveyor belt doesn't just move by itself. It's pushed along by millions of tiny, hair-like structures called cilia. Like a field of wheat in the wind, cilia sway with each inhale and exhale, but do so at a fast clip of up to 16 beats per second. Cilia closer to the nostrils gyrate at a different rhythm than those farther along, their movements creating a coordinated wave that keeps mucus moving deeper. The cilia grip is so strong that it can even push against the force of gravity. No matter what position the nose (and head) is in, whether it's upside down or right-side up, the cilia will keep pushing inward and down.

Working together, the different areas of the turbinates will heat, clean, slow, and pressurize air so that the lungs can extract more oxygen with each breath. This is why nasal breathing is far more healthy and efficient than breathing through the mouth. As Nayak explained when I first met him, the nose is the silent warrior: the gatekeeper of our bodies, pharmacist to our minds, and weather vane to our emotions.

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The magic of the nose, and its healing powers, wasn't lost on the ancients.

Around 1500 BCE, the Ebers Papyrus, one of the oldest medical texts ever discovered, offered a description of how nostrils were supposed to feed air to the heart and lungs, not the mouth. A thousand years later, Genesis 2:7 described how "the Lord God formed man of the dust of the ground, and breathed into his nostrils the breath of life; and man became a living soul." A Chinese Taoist text from the eighth century AD noted that the nose was the "heavenly door," and that breath must be taken in through it. "Never do otherwise," the text warned, "for breath would be in danger and illness would set in."

But it wasn't until the nineteenth century that the Western population ever considered the glories of nasal breathing. It happened thanks to an adventurous artist and researcher named George Catlin.

By 1830, Catlin had left what he called a "dry and tedious" job as a lawyer to become a portrait painter for Philadelphia's high society. He became well-known for his depictions of governors and aristocrats, but all the pomp and pretention of polite society did not impress him. Although his health was failing, Catlin yearned to be far away in nature, to capture rawer and more real depictions of humanity. He packed a gun, several canvases, a few paintbrushes, and headed west. Catlin would spend the next six years traveling thousands of miles throughout the Great Plains, covering more distance than Lewis and Clark to document the lives of 50 Native American tribes.

He went up the Missouri to live with the Lakota Sioux. He met with the Pawnee, Omaha, Cheyenne, and Blackfeet. Along the banks of the Upper Missouri, he happened upon the civilization of the Mandan, a mysterious tribe whose members stood six feet tall and lived in bubble-shaped houses. Many had luminous blue eyes and snow-white hair.

Catlin realized that nobody really knew about the Mandan, or other Plains tribes, because no one of European descent had bothered to spend time talking to them, researching them, living with them, and learning about their beliefs and traditions.

"I am traveling this country, as I have before said, not to advance or to prove *theories*, but to see all I am able to see and to tell it in the simplest and most intelligible manner I can to the world, for their own



conclusions," Catlin wrote. He would paint some 600 portraits and take hundreds of pages of notes, forming what famed author Peter Matthiessen would call "the first, last, and only complete record ever made of the Plains Indians at the height of their splendid culture."

The tribes varied region by region, with different customs, traditions, and diets. Some, like the Mandan, ate only buffalo flesh and maize, while others lived on venison and water, and still others harvested plants and flowers. The tribes looked different, too, with varying hair colors, facial features, and skin tones.

And yet Catlin marveled at the fact that all 50 tribes seemed to share the same superhuman physical characteristics. In some groups, such as the Crow and the Osage, Catlin wrote there were few men, "at their full growth, who are less than six feet in stature, and very many of them six and a half, and others seven feet." They all seemed to share a Herculean make of broad shoulders and barrel chests. The women were nearly as tall and just as striking.

Having never seen a dentist or doctor, the tribal people had teeth that were perfectly straight—"as regular as the keys of a piano," Catlin noted. Nobody seemed to get sick, and deformities and other chronic health problems appeared rare or nonexistent. The tribes attributed their vigorous health to a medicine, what Catlin called the "great secret of life." The secret was breathing.

The Native Americans explained to Catlin that breath inhaled through the mouth sapped the body of strength, deformed the face, and caused stress and disease. On the other hand, breath inhaled through the nose kept the body strong, made the face beautiful, and prevented disease. "The air which enters the lungs is as different from that which enters the nostrils as distilled water is different from the water in an ordinary cistern or a frog-pond," he wrote.

Healthy nasal breathing started at birth. Mothers in all these tribes followed the same practices, carefully closing the baby's lips with their fingers after each feeding. At night, they'd stand over sleeping infants and gently pinch mouths shut if they opened. Some Plains tribes strapped infants to a straight board and placed a pillow beneath their heads, creating a posture that made it much harder to breathe through the mouth. During winter, infants would be wrapped in light clothing and then held at arm's length on warmer days so they'd be less prone to get too hot and begin panting.

All these methods trained children to breathe through their noses, all day, every day. It was a habit they would carry with them the rest of their lives. Catlin described how adult tribal members would even resist smiling with an open mouth, fearing some noxious air might get in. This practice was as "old and unchangeable as their hills," he wrote, and it was shared universally throughout the tribes for millennia.

Twenty years after Catlin explored the West, he set off again, at age 56, to live with indigenous cultures in the Andes, Argentina, and Brazil. He wanted to know if "medicinal" breathing practices extended beyond the Plains. They did. Every tribe Catlin visited over the next several years—dozens of them—shared the same breathing habits. It was no coincidence, he reported, that they also shared the same vigorous health, perfect teeth, and forward-growing facial structure. He wrote about his experiences in *The Breath of Life*, published in 1862. The book was devoted solely to documenting the wonders of nasal breathing and the hazards of mouthbreathing.

Catlin was not only a chronicler of breathing methods; he was a practitioner. Nasal breathing saved his life.

As a boy, Catlin snored and was wracked with one respiratory problem after another. By the time he reached his 30s and first went out West, these problems had become so severe that he'd sometimes spit up blood.



His friends were convinced he had lung disease. Every night Catlin feared he would die.

"I became fully convinced of the danger of the habit [mouthbreathing], and resolved to overcome it," he wrote. Through "sternness of resolution and perseverance," Catlin forced his mouth closed while he slept and always breathed through his nose during waking hours. Soon, there were no more aches, pains, or bleeding. By his mid-30s, Catlin reported feeling healthier and stronger than at any other time in his life. "I at length completely conquered an insidious enemy that was nightly attacking me in my helpless position, and evidently fast hurrying me to the grave," he wrote.

George Catlin would live to be 76, about double the average life expectancy at the time. He credited his longevity to the "great secret of life": to *always* breathe through the nose.

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It's the third night of the nasal breathing phase of the experiment, and I'm sitting up in bed reading, taking slow and easy breaths through my nose. I'm not breathing this way out of some "constant adult conviction," as Catlin wrote. I'm doing it because my lips are taped shut.

Catlin suggested tying a bandage around the jaw at night, but that sounded dangerous and difficult, so I opted for another technique, which I'd heard about months earlier from a dentist who runs a private practice in Silicon Valley.

Dr. Mark Burhenne had been studying the links between mouthbreathing and sleep for decades, and had written a book on the subject. He told me that mouthbreathing contributed to periodontal disease and bad breath, and was the number one cause of cavities, even more damaging than sugar consumption, bad diet, or poor hygiene. (This belief had been echoed by other dentists for a hundred years, and was endorsed by Catlin too.) Burhenne also found that mouthbreathing was both a cause of and a contributor to snoring and sleep apnea. He recommended his patients tape their mouths shut at night.

"The health benefits of nose breathing are undeniable," he told me. One of the many benefits is that the sinuses release a huge boost of nitric oxide, a molecule that plays an essential role in increasing circulation and delivering oxygen into cells. Immune function, weight, circulation, mood, and sexual function can all be heavily influenced by the amount of nitric oxide in the body. (The popular erectile dysfunction drug sildenafil, known by the commercial name Viagra, works by releasing nitric oxide into the bloodstream, which opens the capillaries in the genitals and elsewhere.)

Nasal breathing alone can boost nitric oxide sixfold, which is one of the reasons we can absorb about 18 percent more oxygen than by just breathing through the mouth. Mouth taping, Burhenne said, helped a five-year-old patient of his overcome ADHD, a condition directly attributed to breathing difficulties during sleep. It helped Burhenne and his wife cure their own snoring and breathing problems. Hundreds of other patients reported similar benefits.

The whole thing seemed a little sketchy until Ann Kearney, a doctor of speech-language pathology at the Stanford Voice and Swallowing Center, told me the same. Kearney helped rehabilitate patients who had swallowing and breathing disorders. She swore by mouth taping.

Kearney herself had spent years as a mouthbreather due to chronic congestion. She visited an ear, nose, and throat specialist and discovered that her nasal cavities were blocked with tissue. The specialist advised that the only way to open her nose was through surgery or medications. She tried mouth taping instead.

"The first night, I lasted five minutes before I ripped it off," she told me. On the second night, she was able to tolerate the tape for ten minutes. A couple of days later, she slept through the night. Within six weeks, her nose opened up.



"It's a classic example of use it or lose it," Kearney said. To prove her claim, she examined the noses of 50 patients who had undergone laryngectomies, a procedure in which a breathing hole is cut into the throat. Within two months to two years, every patient was suffering from complete nasal obstruction.

Like other parts of the body, the nasal cavity responds to whatever inputs it receives. When the nose is denied regular use, it will atrophy. This is what happened to Kearney and many of her patients, and to so much of the general population. Snoring and sleep apnea often follow.

Keeping the nose constantly in use, however, trains the tissues inside the nasal cavity and throat to flex and stay open. Kearney, Burhenne, and so many of their patients healed themselves this way: by breathing from their noses, all day and all night.

How to apply mouth tape, or "sleep tape" as it's also called, is a matter of personal preference, and everyone I talked to had their own technique. Burhenne liked to place a small piece horizontally over the lips; Kearney preferred a fat strip over the entire mouth. The internet was filled with suggestions. One guy used eight pieces of inch-wide tape to create a sort of tape goatee. Another used duct tape. A woman suggested taping the entire lower half of the face.

To me, these methods are ridiculous and excessive. Looking for an easier way, over the last few days I conducted my own experiments with blue painter's tape, which smelled weird, and Scotch tape, which crinkled. Band-Aids were too sticky.

Eventually I realized that all I or anyone really needed was a postage-stamp-size piece of tape at the center of the lips—a Charlie Chaplin mustache moved down an inch. That's it. This approach felt less claustrophobic and allowed a little space on the sides of the mouth if I needed to cough or talk. After much trial and error, I settled on 3M Nexcare Durapore "durable cloth" tape, an all-purpose surgical tape with a gentle adhesive. It was comfortable, had no chemical scent, and didn't leave residue.

In the three nights since I started using this tape, I went from snoring four hours to only ten minutes. I'd been warned by Burhenne that sleep tape won't do anything to help treat sleep apnea. My experience suggested otherwise. As my snoring disappeared, so did apnea.

I'd suffered up to two dozen apnea events in the mouthbreathing phase, but last night had zero. I suffered no creepy insomniac hallucinations, no late-night ruminations on *Homo habilis* or Edward Gorey. I never woke up needing to pee. I didn't have to, because my pituitary gland was likely releasing vasopressin. I was finally sleeping soundly.

Meanwhile, Olsson went from snoring half the night to not snoring for even a minute. His apnea events dropped from 53 to zero. The bright-eyed, cotton-haired Swede I'd felt so guilty about abusing had been reborn. Earlier today he was smiling, so convinced of sleep tape's healing power that he kept a piece of it stuck to his lips for the rest of the morning.

Sleep, and life, had become something that Olsson and I embraced again. Now, sitting in bed, with a little stamp of white tape stuck to my lips, I flipped to the last page in Catlin's *Breath of Life*, the final paragraph he'd ever publish in his long life of research.

"And if I were to endeavor to bequeath to posterity the most important Motto which human language can convey, it should be in three words—SHUT-YOUR-MOUTH. . . . Where I would paint and engrave it, in every *Nursery*, and on every *Bed-post* in the Universe, its meaning could not be mistaken.

"And if obeyed," he continued, "its importance would soon be realized."

Four

# EXHALE

Every morning at 9:00, after Olsson and I have finished our testing and split off for solo time, I roll out a mat on my living room floor and work on becoming a little more immortal.

The path to everlasting life involves a lot of stretching: back bends, neck bends, and twirling, each one a holy and ancient practice that had been passed down in secrecy from one Buddhist monk to another for 2,500 years. Olsson and I need this stretching; even if we breathe through the nose twenty-four hours a day, it won't help much unless we've got the lung capacity to hold in that air. Just a few minutes of daily bending and breathing can expand lung capacity. With that extra capacity we can expand our lives.

The stretches, called the Five Tibetan Rites, came to the Western world, and to me, by way of writer Peter Kelder, who was known as a lover of "books and libraries, words and poetry."

In the 1930s, Kelder was sitting on a park bench in southern California when an elderly stranger struck up a conversation. The man, whom he called Colonel Bradford, had spent decades in India with the British Army. The Colonel was old—all sloping shoulders, gray hair, and wobbly legs—but he believed there was a cure for aging and that it was locked up in a monastery in the Himalayas. The usual mystical stuff occurred up there: the sick became healthy, poor became rich, old became young. Kelder and the Colonel stayed in touch and shared many conversations. Then, one day, the old man hobbled away, desperate to find this Shangri-La before he drew his last breath.

Four years passed until Kelder received a call from his building's doorman. The Colonel was waiting downstairs. He looked 20 years younger. He was standing straight, his face vibrant and alive, and his once-balding head was covered in thick, dark hair. He'd found the monastery, studied the ancient manuscripts, and learned restorative practices from the monks. He'd reversed aging through nothing more than stretching and breathing.

Kelder described these techniques in a slim booklet titled *The Eye of Revelation,* published in 1939. Few people bothered to read it; fewer believed it. Kelder's yarn was likely fabricated, or at minimum grossly exaggerated. However, the lung-expanding stretches he described are rooted in actual exercises that date back to 500 BCE. Tibetans had used these methods for millennia to improve physical fitness, mental health, cardiovascular function, and, of course, extend life.

More recently, science has begun measuring what the ancient Tibetans understood intuitively. In the 1980s, researchers with the Framingham Study, a 70-year longitudinal research program focused on heart disease, attempted to find out if lung size really did correlate to longevity. They



gathered two decades of data from 5,200 subjects, crunched the numbers, and discovered that the greatest indicator of life span wasn't genetics, diet, or the amount of daily exercise, as many had suspected. It was lung capacity.

The smaller and less efficient lungs became, the quicker subjects got sick and died. The cause of deterioration didn't matter. Smaller meant shorter. But larger lungs equaled longer lives.

Our ability to breathe full breaths was, according to the researchers, "literally a measure of living capacity." In 2000, University of Buffalo researchers ran a similar study, comparing lung capacity in a group of more than a thousand subjects over three decades. The results were the same.

What neither of these landmark studies addressed, however, was how a person with deteriorated lungs might heal and strengthen them. There were surgeries to remove diseased tissue and drugs to stem infections, but no advice on how to keep lungs large and healthy throughout life. All the way up to the 1980s, the common belief in Western medicine was that the lungs, like every other internal organ, were immutable. That is, whatever lungs we were born with, we were stuck with. As these organs degraded with age, the only thing we could do was sigh and bear it.

Aging was supposed to go like this: Starting around 30, we should expect to lose a little more memory, mobility, and muscle with every passing year. We would also lose the ability to breathe properly. Bones in the chest would become thinner and change shape, causing rib cages to collapse inward. Muscle fibers surrounding the lungs would weaken and prevent air from entering and exiting. All these things reduce lung capacity.

The lungs themselves will lose about 12 percent of capacity from the age of 30 to 50, and will continue declining even faster as we get older, with women faring worse than men. If we make it to 80, we'll be able to take in 30 percent less air than we did in our 20s. We're forced to breathe faster and harder. This breathing habit leads to chronic problems like high blood pressure, immune disorders, and anxiety.

But what the Tibetans have long known and what Western science is now discovering is that aging doesn't have to be a one-way path of decline. The internal organs are malleable, and we can change them at nearly any time.

Freedivers know this better than anyone. I'd learned it from them years ago, when I met several people who had increased their lung capacity by an astounding 30 to 40 percent. Herbert Nitsch, a multiple world record holder, reportedly has a lung capacity of 14 liters—more than *double* that of the average male. Neither Nitsch nor any of the other freedivers started out like this; they made their lungs larger by force of will. They taught themselves how to breathe in ways that dramatically changed the internal organs of their bodies.

Fortunately, diving down hundreds of feet is not required. Any regular practice that stretches the lungs and keeps them flexible can retain or increase lung capacity. Moderate exercise like walking or cycling has been shown to boost lung size by up to 15 percent.

These discoveries would have been welcome news to Katharina Schroth, a teenager who lived in Dresden, Germany, in the early 1900s. Schroth had been diagnosed with scoliosis, a sideways curvature of the spine. The condition had no cure, and most children who suffered from extreme cases like Schroth's could expect to spend a life in bed or rolling around in a wheelchair.

Schroth had other thoughts about the human body's potential. She'd watched how balloons collapsed or expanded, pushing or pulling in whatever was around them. The lungs, she felt, were no different. If she could expand her lungs, maybe she could also expand her skeletal



structure. Maybe she could straighten her spine and improve the quality and quantity of her life.

At age 16, Schroth began training herself in something called "orthopedic breathing." She would stand in front of a mirror, twist her body, and inhale into one lung while limiting air intake to the other. Then she'd hobble over to a table, sling her body on its side, and arch her chest back and forth to loosen her rib cage while breathing into the empty space. Schroth spent five years doing this. At the end, she'd effectively cured herself of "incurable" scoliosis; she'd breathed her spine straight again.

Schroth began teaching the power of breathing to other scoliosis patients, and by the 1940s she was running a bustling institute in rural western Germany. It had no hospital rooms or other standard medical equipment; just a few run-down buildings, a yard, a picket fence, and patio tables. One hundred fifty scoliosis patients would gather there at a time. They suffered from the most severe form of the disease, with spines curved more than 80 degrees. Many were so hunched over, their backs so twisted and turned, that they couldn't walk or even look upward. Their disfigured ribs and chests made it hard for them to take a breath, and they likely suffered from respiratory problems, fatigue, and heart conditions because of it. Hospitals had given up on trying to heal these patients. They came to live with Schroth for six weeks.

The German medical community derided Schroth, claiming that she was neither a professional trainer nor a physician and was not qualified to treat patients. She ignored them all; she kept doing things her way, having the women strip down bare-chested in a dirt lot beneath a copse of beech trees, stretching and breathing themselves back to health. Within a few weeks, hunched backs straightened and many students gained inches in height. Women who had been bedridden and hopeless finally began to walk again. They could take full breaths again.

Schroth spent the next 60 years bringing her techniques to hospitals throughout Germany and beyond. Toward the end of her life, the medical community had changed its tune and the German government awarded Schroth the Federal Cross of Merit for her contributions to medicine.

"What the bodily form depends on is breath (chi) and what breath relies upon is form," states a Chinese adage from 700 AD. "When the breath is perfect, the form is perfect (too)."

Schroth continued to expand her lungs and improve her own breathing and form throughout her life. This former scoliosis patient, who as a teenager had been left to wither in bed, would die in 1985, just three days shy of her 91st birthday.

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Midway through my research for this book, I took a trip to New York City to meet a more contemporary breathing expert who offered a different approach to expanding the lungs and longevity. Her apartment workspace was located a few blocks from the United Nations in a brown brick building with an awning covered in pink-eyed pigeons. I walked past a drowsy doorman, rode up an elevator, and a minute later I was knocking at room 418.

Lynn Martin welcomed me in. She was beanpole thin and dressed in a black jumpsuit with an oversize brass-buckled belt. "I told you it was small!" she said of the studio apartment. Surrounding us were manila folders, human anatomy books, and a few plastic models of human lungs. On a wall beside a bookshelf were black-and-white photos of Martin in the early 1970s. In one, she was wearing a black leotard in mid-glide on the wood floor of a dance studio, her blond hair pulled back in a lazy ponytail, her face bearing an uncanny resemblance to *Rosemary's Baby*–era Mia Farrow.



After a few pleasantries, Martin sat me down and started telling me what I came to hear. "He was very verbal, but when you asked what exactly he was doing, he could never explain it," she said. "Nobody since has ever been able to do what he did."

The subject of intrigue was Carl Stough, a choir conductor and medical anomaly who got his start in the 1940s. Of all the pulmonauts I'd come across over the past several years, Stough was the most elusive. He published one book in 1970, which quickly flopped and went out of print. Twenty years later, a CBS producer put together a one-hour program about his groundbreaking work, but it never aired. Stough himself didn't advertise his techniques. He never went on speaking tours. Even so, professional opera singers, Grammy-winning saxophonists, paraplegics, and dying emphysemics—thousands of them—managed to find him. Stough broke all the rules; he expanded lungs and extended life spans. And yet, most people today have never heard of him.

Martin had worked with Stough for more than two decades. She was a living link to this mysterious man and his research in the lost art of breathing. What Stough had discovered, and what Martin had learned, was that the most important aspect of breathing wasn't just to take in air through the nose. Inhaling was the easy part. The key to breathing, lung expansion, and the long life that came with it was on the other end of respiration. It was in the transformative power of a full exhalation.

Photographs of Stough from the 1940s show an upright man who bore a passing resemblance to Thurston Howell III, the millionaire from *Gilligan's Island*. Stough liked to sing and teach singing. He noticed how his fellow singers would belt out a few measures, stop to take a breath, and then belt out a few more. Each seemed to be gasping for air, holding it high in the chest, and releasing it too soon. Singing, talking, yawning, sighing—any vocalization we make occurs during the exhalation. Stough's students had thin and weak voices because, he believed, they had thin and weak exhalations.

While directing choirs at Westminster Choir College in New Jersey, Stough began training his singers to exhale properly, to build up their respiratory muscles and enlarge their lungs. Within a few sessions, the students were singing clearer, more robustly, and with added nuance. He moved to North Carolina to conduct church choirs that went on to win national competitions, and his choir appeared on a weekly program broadcast nationally by Liberty Radio Network. Stough became so renowned that he moved to New York to retrain singers at the Metropolitan Opera.

In 1958, the administration of the East Orange Veterans Affairs Hospital in New Jersey called. "You must know something about breathing that we don't," said Dr. Maurice J. Small, the chief of tuberculosis management. Small was wondering if Stough might be interested in training a new group of students. None of them could sing, and a few couldn't walk or talk. They were emphysema patients, and they were in desperate need of help.

When Stough arrived at the East Orange hospital weeks later, he was horrified. Dozens of patients were laid out on gurneys, each one jaundiced and pale, their mouths craned open like fish, oxygen tubes pumping to no avail. The hospital staff didn't know what to do, so they just wheeled the men across the waxed terrazzo floors and into a room hung with faded-yellow tissue dispensers and American flag clocks, one patient beside the other, waiting to die. It had gone this way for 50 years.

"I foolishly had assumed that everyone had at least a rudimentary knowledge of physiology," Stough wrote in his autobiography, *Dr. Breath*. "Even more foolishly I had assumed that a universal awareness of the importance of breathing existed. Nothing could have been farther from the truth."

Emphysema is a gradual deterioration of lung tissue marked by chronic



bronchitis and coughing. The lungs become so damaged that people with the disease can no longer absorb oxygen effectively. They're forced to take several short breaths very fast, often breathing in far more air than they need, but still feel out of breath. Emphysema had no known cure.

The nurses, meaning well, had placed cushions under patients' backs so that their chests were arched up. The idea was to create elevation to ease inhalations. Stough instantly saw that this was making the condition worse.

Emphysema, he realized, was a disease of exhalation. The patients were suffering not because they couldn't get fresh air into their lungs, but because they couldn't get enough stale air out.

Normally, the blood coursing through our arteries and veins at any one time does a full circuit once a minute, an average of 2,000 gallons of blood a day. This regular and consistent blood flow is essential to delivering fresh oxygenated blood to cells and removing waste.

What influences much of the speed and strength of this circulation is the thoracic pump, the name for the pressure that builds inside the chest when we breathe. As we inhale, negative pressure draws blood into the heart; as we exhale, blood shoots back out into the body and lungs, where it recirculates. It's similar to the way the ocean floods into shore, then ebbs out.

And what powers the thoracic pump is the diaphragm, the muscle that sits beneath the lungs in the shape of an umbrella. The diaphragm lifts during exhalations, which shrinks the lungs, then it drops back down to expand them during inhalations. This up-and-down movement occurs within us some 50,000 times a day.

A typical adult engages as little as 10 percent of the range of the diaphragm when breathing, which overburdens the heart, elevates blood pressure, and causes a rash of circulatory problems. Extending those breaths to 50 to 70 percent of the diaphragm's capacity will ease cardiovascular stress and allow the body to work more efficiently. For this reason, the diaphragm is sometimes referred to as "the second heart," because it not only beats to its own rhythm but also affects the rate and strength of the heartbeat.

Stough discovered that the diaphragms in all of the East Orange emphysema patients had broken down. X-rays showed that they were extending their diaphragms by only a fraction of what was healthy, taking only a sip of air with each breath. The patients had been sick so long that many of the muscles and joints around their chests had atrophied and stiffened; they had no muscle memory of breathing deep. Over the next two months, Stough reminded them how.

"My activities looked silly when observed from a distance, and they seemed silly at the outset to the person with whom I worked," wrote Stough.

He'd begin the treatments by putting patients flat on their backs, running his hands across their torsos, and gently tapping on rigid muscles and distended chests. He'd have them hold their breath and count from one to five as many times in a row as they could. Next, he massaged their necks and throats and lightly coaxed their ribs as he told them to inhale and exhale *very slowly*, trying to wake the diaphragm from its long slumber. Each of these exercises allowed the patients to let out a little more air so that a little more air could get in.

After several sessions, some patients learned to speak a full sentence in a single breath for the first time in years. Others began walking.

"One elderly man who had not been able to walk across the room not only could walk but could walk up the hospital stairs, a remarkable feat for an advanced emphysema patient," Stough wrote. Another man, who hadn't been able to breathe for more than 15 minutes without supplemental oxygen, was lasting eight hours. A 55-year-old man who had suffered advanced emphysema for eight years was able to leave the hospital and captain a boat down to Florida.



Before-and-after X-rays showed that Stough's patients were vastly expanding their lung capacity in only a few weeks. Even more stunning, they were training an involuntary muscle—the diaphragm—to lift higher and drop lower. Administrators told Stough that this was medically impossible; internal organs and muscles cannot be developed, they said. At one point, several doctors petitioned to ban Stough from treating patients and kick him out of the hospital system. Stough was a choral teacher, not a doctor, after all. But the X-rays didn't lie. To confirm his results, Stough began recording the first footage of a moving diaphragm, using a new X-ray film technology called cinefluorography. Everyone was floored.

"I told Carl in no uncertain words that he was mildly demented to say that he could effect a rise in the diaphragm and a descent in the ribs, but then in one patient we got rather spectacular results showing that he did do this," said Dr. Robert Nims, the chief of pulmonary medicine at the West Haven VA Hospital in Connecticut. "We have shown that he's able to decrease the volume of the lungs [via deep exhalations] more than any pulmonary man would say it was possible."

Stough hadn't found a way to reverse emphysema. Lung damage from the disease is permanent. What he'd done is find a way to access the rest of the lungs, the areas that were still functioning, and engage them on a larger level. The "cure" Stough professed was de facto, but it worked.

Over the next decade, Stough would take his treatment to a half-dozen of the largest VA hospitals on the East Coast, sometimes working on patients seven days a week. He'd go on to treat not only emphysema, but asthma, bronchitis, pneumonia, and more.

The benefits of breathing, of harnessing the art of exhalation, Stough found, extended not just to the chronically sick or to singers, but to everyone.

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Back in Lynn Martin's apartment, I was reawakening my own slumbering diaphragm on the living room futon. "This is not a massage," Martin said, making her point as she pressed a hand against my ribs. I drew soft and long breaths deep into my abdomen while Martin helped loosen my rib cage, trying to coax at least 50 percent of my maximum diaphragm movement with each inhale and exhale.

Breathing this way wasn't necessary, Martin told me. Our bodies can survive on short and clipped breaths for decades, and many of us do. That doesn't mean it's good for us. Over time, shallow breathing will limit the range of our diaphragms and lung capacity and can lead to the high-shouldered, chest-out, neck-extended posture common in those with emphysema, asthma, and other respiratory problems. Fixing this breathing and this posture, she told me, was relatively easy.

After several rounds of deep breaths to open my rib cage, Martin asked me to start counting from one to ten over and over with every exhale. "*1, 2, 3, 4, 5, 6, 7, 8, 9, 10; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10*—then keep repeating it," she said. At the end of the exhale, when I was so out of breath I couldn't vocalize anymore, I was to keep counting, but to do so silently, letting my voice trail down into a "sub-whisper."

I ran through a few rounds, counting quickly and loudly, then silently mouthing the numbers. At the end of each breath, it felt like my chest had been plastic-wrapped and my abs had just gone through a brutal workout. "Keep going!" Martin said.

The strain of the counting exercise is equivalent to the strain on the lungs during physical exertion. This was what made the exercise so effective for Stough's bedridden patients. The point was to get the diaphragm accustomed to this wider range so that deep and easy breathing became unconscious. "Keep moving your lips!" Martin egged me on. "Get out the last little molecule of air!"



After a few more minutes of counting, silent and otherwise, I stopped and took a break and felt my diaphragm chugging away like a piston in slow motion, radiating fresh blood from the center of my body. This is the feeling of what Stough called "Breathing Coordination," when the respiratory and circulatory systems enter a state of equilibrium, when the amount of air that enters us equals the amount that leaves, and our bodies are able perform all their essential functions with the least exertion.

In 1968, Stough left the VA system and his thriving private practice in New York to train yet another group of students. These people could talk, and they could walk, and they could run very fast. They were the runners on the Yale track and field team, among the best in the nation at the time. When Stough arrived at the track fieldhouse, the athletes were so excited that they hung a poster on the bulletin board outside: *Dr. Breath Is Here Today!*

Stough had expected these elite athletes to have exemplary breathing habits. Instead, he found that they suffered from the same "respiratory weakness" as everyone else: they got the same colds and flus and lung infections. Most of them breathed way too often, high in their chests. Sprinters were the worst off. The short and violent breaths they took during runs put too much pressure on delicate tissues and bronchial tubes. As a result, they suffered from asthma and other respiratory ailments. At the finish line, they coughed and sometimes vomited and collapsed, wheezing in pain.

"I had observed that in recovering from performance, athletes tended to adopt the same breathing characteristics as those the emphysema patients exhibited," Stough wrote. These runners had been trained to push through the pain, and they did. They won competitions, but they were harming their bodies.

Stough laid out a table at the Yale indoor track, sat the runners on it, and began running his hands up and around their chests in front of a crowd of onlookers. He warned them to never hold their breath when positioned at the starting line at the beginning of a race, but to breathe deeply and calmly and always exhale at the sound of the starter pistol. This way, the first breath they'd take in would be rich and full and provide them with energy to run faster and longer.

After only a few sessions, all the runners reported feeling better and breathing better. "I never felt so relaxed in my life," one sprinter said. They took half the time to recover between races and were soon breaking personal bests and edging toward world records.

On the heels of the Yale success, Stough moved to South Lake Tahoe to train Olympic runners preparing for the 1968 Summer Olympics in Mexico City. Same therapy, same success. A decathlete went out to the track and broke his previous record. Another broke his lifetime record. A runner named Rick Sloan broke his two life records for three events.

"Through my work with Dr. Stough, I knew I had to exhale," said Lee Evans, an Olympic sprinter. "You know, I exhale, which kept my energy up. I didn't get tired. . . . But after the game, I found that this was for my life."

You might recognize Evans. He's the man in the famous photograph standing on the center podium at the Olympics awards ceremony, wearing a Black Panther beret and jutting a fist in the air. He won gold in the 400 meters and another in the 400-meter relay. The rest of the 1968 U.S. men's team under Stough's training went on to win a total of 12 Olympic medals, most gold, and set five world records. It was one of the greatest performances in an Olympics. The Americans were the only runners to not use oxygen before or after a race, which was unheard of at the time.

They didn't need to. Stough had taught them the art of breathing coordination, and the power of harnessing a full exhalation.

"He was doing so many things at once," Lynn Martin says as we moved from the futon back to the dining room table at the center of her studio



apartment. "The sensitivity of his hands, perfect pitch of his ears, the natural knack for instruction—all of it." For the past few minutes, Martin has been telling me about her time working with Stough, how she'd gone to see him in 1975 on the recommendation of another dancer and had come out feeling transformed. She returned weeks later and took a job at the clinic. Even though Martin would spend more than two decades working with Stough as one of his closest associates, he never told her his secrets. "He thought it was too difficult to put into words," she said.

I could relate. I'd seen a video recording of Stough at the 1992 Aspen Music Festival—the only existing footage that demonstrates what he did and how he did it. It opened with a frame that read: *An Introduction to Respiratory Science: The Preventative Medicine of the Twenty-First Century*. Stough was at the center of a conference room, a massage table in front of him. An open window looked out over a thicket of pine trees glowing white in the summer sun. Stough was deeply tanned and dressed in a black blazer with brass buttons and a pocket kerchief, as if he'd just flown in on a Concorde from Monte Carlo.

He started off by inviting a tenor named Timothy Jones to lie on the table and proceeded to jiggle Jones's jaw, dig his hands into his waist, and rock him back and forth. "You see, I have to keep tapping right on the chest," said Stough, his yellow polka-dot tie dangling in Jones's hair. This went on for several minutes, until Stough leaned three inches from Jones's face and began to count from one to ten with him in a gibberishy harmony. "Everything's loosening very fast!" Stough announced. He wiggled Jones's hips and neck so violently that the singer almost fell off the table.

It was a bizarre spectacle, and the grabbing and pushing and deep stroking looked at times like borderline molestation. After my own experience in Martin's studio for an hour, babbling numbers and having my chest poked and ribs squeezed, it became more clear to me why

Stough's work never caught on. It didn't matter that saxophonist David Sanborn and asthmatic opera singers, Olympic runners, and hundreds of emphysema survivors praised his treatments as a lifesaver. Stough wasn't a doctor; he was a self-made pulmonaut, a choir conductor. He was just too far out there. His therapy was just too weird.

"Although the process of breathing involves both anatomy and physiology, neither branch of science has claimed it for thorough exploration," wrote Stough. "It was a little-known territory waiting to be mapped and charted."

Stough made his map over a half century of constant work. But when he died, that map was lost. As soon as he left the VA wards, so did his therapy.

. . .

At the end of my two-hour Breathing Coordination session, I left Martin's apartment and hopped on the train back to Newark Liberty International Airport. As we rumbled across the marshlands and over the Passaic River, I searched through the current treatments for the nearly 4 million Americans now suffering from emphysema. There were bronchodilators, steroids, and antibiotics. There was supplemental oxygen and surgery and something called pulmonary rehabilitation, which included assistance to quit smoking, exercise planning, nutrition counseling, and some pursed-lip breathing techniques.

But there was no mention of Stough, or the "second heart" of the diaphragm, or the importance of a full exhalation. No mention of how expanding the lungs and breathing properly had effectively reversed the disease or lengthened lives. Emphysema was still listed as an incurable condition.

Five

# SLOW

"Could you hand me the oximeter?" Olsson asks from across the dining room table. It's afternoon on the fifth day of the Recovery phase, and for the past 30 minutes we've been testing our pH levels, blood gases, heart rates, and other vital signs. This is the 45th time we've been through this drill in the past two weeks.

Although both Olsson and I feel utterly transformed while nasal breathing, the monotony of the days is becoming maddening. We're eating the same food at the same time as we did ten days earlier, sweating through the same stationary bike workouts in the same gym, and having many of the same conversations. This afternoon we're discussing Olsson's favorite subject, his obsession for the past decade. We are, once again, talking about carbon dioxide.

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It is hard to admit now, but when I first interviewed Olsson more than a year ago, he was not a source I entirely trusted. On our Skype calls, he liked to hammer the importance of slow breathing, and he'd sent me a half-dozen PowerPoint presentations and reams of scientific studies on how paced breathing relaxed the body and calmed the mind. This part made perfect sense. But when he started in on the restorative wonders of a toxic gas, I began to wonder. "I really think carbon dioxide is more important than oxygen," he told me.

Olsson claimed that we have 100 times more carbon dioxide in our bodies than oxygen (which is true), and that most of us need even more of it (also true). He said it wasn't just oxygen but huge quantities of carbon dioxide that fostered the burst of life during the Cambrian Explosion 500 million years ago. He said that, today, humans can increase this toxic gas in our bodies and sharpen our minds, burn fat, and, in some cases, heal disease.

After a while I began to worry that Olsson was nuts, or at least prone to gross exaggeration, and that our hours of conversations had been a waste of time.

Carbon dioxide, after all, is a metabolic waste product. It's the stuff that plumes out of coal plants and rotten fruit. The instructor at a boxing class I attended used to beseech students to "breathe deep and get all that carbon dioxide out of your system." This seemed like good advice. Every other day, a new headline detailed how Earth was warming because there was too much carbon dioxide in the atmosphere. Animals were dying. Carbon dioxide kills.

Olsson kept arguing the opposite. He insisted that carbon dioxide could be beneficial, and he warned me that too much oxygen in my body wouldn't help me but hurt me. "Breathing heavy, breathing quickly and as deeply as you can—I realized this is the worst advice anyone could give you," Olsson told me. Big, heavy breaths were bad for us because they depleted our bodies of, yes, carbon dioxide.

Several months of this back-and-forth got me intrigued enough, or



confused enough, or both, that I decided to fly to Sweden, spend a few days with Olsson, and see his operation in an attempt to learn more about one of the most misunderstood gases in the universe.

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I arrived in Stockholm in mid-November and took a train to an industrial co-working space on the outskirts of town. Through the windows of a cavernous lobby, the sunlight had a kind of slant to it. Ominous clouds gathered, and the air was thick with the heavy feeling that precedes a long winter.

Olsson showed up exactly on time, took a seat across from me, and placed a glass of water on the table. He wore faded jeans, white tennis shoes, and a pressed white shirt. He had the kind of calm you see in monks, Amish, and others who spend a lot of time in their inner worlds. When he spoke, it was always softly, and with that annoying habit that all Scandinavians seem to have inherited: flawless English, with no *umms* or *huhs* or pauses. He'd even gotten his *whoms* down and inserted the oft-forgotten "not" when he told me how he could care less.

"I was going to end up exactly like my father," Olsson said, running a finger along the condensation of the water glass. He told me how his father had been chronically stressed, how he breathed too much, and how he'd gotten severe high blood pressure and lung disease and died at 68 with a breathing tube in his mouth. "I knew that so many other people were going to stay sick and die of the same thing," Olsson explained. He wanted to educate himself so he'd be prepared if something else happened to him or his family.

After the long days he spent running a software distribution company, he'd come home and read medical books. He talked to doctors, surgeons, instructors, and research scientists. Eventually he sold his business, got rid of his nice cars and big house, got a divorce, and moved into a condominium. Then he scaled down to a smaller apartment and spent six years forgoing any salary, working almost entirely alone, trying to understand the mysteries of health, medicine, and most specifically breathing and the role of carbon dioxide in the body. "There were yogi books about prana and then there were medical books focusing on pathologies—blood gases and disease and CPAP," he said.

In short, Olsson found what I'd found, but years earlier: that there was a gap in our knowledge about the science of breathing and its role in our bodies. He discovered that we'd done a good job of examining what causes breathing problems but done little to explore how they first develop and how we might prevent them.

Olsson was in good company. Doctors had been complaining about this for decades. "The field of respiratory physiology is expanding in all directions, yet so preoccupied have most physiologists been with lung volumes, ventilation, circulation, gas exchange, the mechanics of breathing, the metabolic cost of breathing and the control of breathing that few have paid much attention to the muscles that actually do the breathing," one physician wrote in 1958. Another wrote: "Until the seventeenth century most of the great physicians and anatomists were interested in the respiratory muscles and the mechanics of breathing. Since then these muscles have been increasingly neglected, lying as they do in a no-man's land between anatomy and physiology."

What many of these doctors found, and what Olsson would discover much later, was that the best way to prevent many chronic health problems, improve athletic performance, and extend longevity was to focus on how we breathed, specifically to balance oxygen and carbon dioxide levels in the body. To do this, we'd need to learn how to inhale and exhale slowly.



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How could inhaling smaller amounts of air and having more carbon dioxide in our bloodstream increase oxygen in our tissues and organs? How could doing less give us more?

To understand this contrarian concept, you need to consider the body parts beyond the nose and mouth. Those structures, after all, are simply the gateways for the long journey of breath. The purpose of the 25,000 inhales and exhales we take daily lies deeper inside us. And the farther we follow this air, the more surprising and strange the journey gets.

Your body, like all human bodies, is essentially a collection of tubes. There are wide tubes, like the throat and sinuses, and very thin tubes like capillaries. The tubes that make up the tissues of the lungs are very small, and we've got a lot of them. If you lined up all the tubes in the airways of your body, they'd reach from New York City to Key West—more than 1,500 miles.

Each breath you take must first travel down the throat, past a crossroads called the tracheal carina, which splits it into the right and left lungs. As it keeps going, that breath gets pushed into smaller tubes called the bronchioles until it dead-ends at 500 million little bulbs called the alveoli.

What happens next is complicated and confusing. An analogy may help.

Let's say you're about to take a river cruise. You're in a waiting room at the dock when a ship approaches. You pass through security, board the ship, and head off. This is similar to the path oxygen molecules take once they reach the alveoli. Each of these little "docking stations" is surrounded by a river of plasma filled with red blood cells. As these cells pass by, oxygen molecules will slip through the membranes of the alveoli and lodge themselves inside one.

The cellular cruise ship is filled with "guest rooms." In your blood cells, those rooms are the protein called hemoglobin. Oxygen takes a seat inside a hemoglobin; then the red blood cells journey upstream, deeper into the body.

As blood passes through tissues and muscles, oxygen will disembark, providing fuel to hungry cells. As oxygen offloads, other passengers, namely carbon dioxide—the "waste product" of metabolism—will pile aboard, and the cruise ship will begin a return journey back to the lungs.

This exchange of oxygen and carbon dioxide changes the appearance of blood. The blood cells in the veins that carry more carbon dioxide will appear blue; arterial blood, still filled with oxygen, will appear bright red. It's these gases that give veins and arteries their distinctive colors.

Eventually, the cruise ship will make its round through the body and back to port, back to the lungs, where carbon dioxide will exit the body through the alveoli, up the throat, and out the mouth and nose in an exhale. More oxygen boards in the next breath and the process starts again.

Every healthy cell in the body is fueled by oxygen, and this is how it's delivered. The entire cruise takes about a minute, and the overall numbers are staggering. Inside each of our 25 trillion red blood cells are 270 million hemoglobin, each of which has room for four oxygen molecules. That's *a billion molecules of oxygen* boarding and disembarking within each red blood cell cruise ship.

There's nothing controversial about this process of respiration and the role of carbon dioxide in gas exchange. It's basic biochemistry. What's less acknowledged is the role carbon dioxide plays in weight loss. That carbon dioxide in every exhale has weight, and we exhale more weight than we inhale. And the way the body loses weight isn't through profusely sweating or "burning it off." We lose weight through exhaled breath.



For every ten pounds of fat lost in our bodies, eight and a half pounds of it comes out through the lungs; most of it is carbon dioxide mixed with a bit of water vapor. The rest is sweated or urinated out. This is a fact that most doctors, nutritionists, and other medical professionals have historically gotten wrong. The lungs are the weight-regulating system of the body.

"Everyone always talks about oxygen," Olsson told me during our interview in Stockholm. "Whether we breathe thirty times or five times a minute, a healthy body will always have enough oxygen!"

What our bodies really want, what they require to function properly, isn't faster or deeper breaths. It's not more air. What we need is more carbon dioxide.

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More than a century ago, a baggy-eyed Danish physiologist named Christian Bohr discovered this in a laboratory in Copenhagen. By his early 30s, Bohr had earned degrees in medicine and physiology and was working at the University of Copenhagen. He was fascinated with respiration; he knew that oxygen was the cellular fuel and that hemoglobin was the transporter. He knew that when oxygen went into a cell, carbon dioxide came out.

But Bohr didn't know *why* this exchange took place. Why did some cells get oxygen more easily than others? What directed billions of hemoglobin molecules to release oxygen at just the right place at the right time? How did breathing really work?

He began experimenting. Bohr gathered chickens, guinea pigs, grass snakes, dogs, and horses, and measured how much oxygen the animals consumed and how much carbon dioxide they produced. Then he drew blood and exposed it to different mixtures of these gases. Blood with the most carbon dioxide in it (more acidic) loosened oxygen from hemoglobin. In some ways, carbon dioxide worked as a kind of divorce lawyer, a go-between to separate oxygen from its ties so it could be free to land another mate.

This discovery explained why certain muscles used during exercise received more oxygen than lesser-used muscles. They were producing more carbon dioxide, which attracted more oxygen. It was supply on demand, at a molecular level. Carbon dioxide also had a profound dilating effect on blood vessels, opening these pathways so they could carry more oxygen-rich blood to hungry cells. Breathing less allowed animals to produce more energy, more efficiently.

Meanwhile, heavy and panicked breaths would purge carbon dioxide. Just a few moments of heavy breathing above metabolic needs could cause reduced blood flow to muscles, tissues, and organs. We'd feel lightheaded, cramp up, get a headache, or even black out. If these tissues were denied consistent blood flow for long enough, they'd break down.

In 1904, Bohr published a paper called "Concerning a Biologically Important Relationship—The Influence of the Carbon Dioxide Content of Blood on Its Oxygen Binding." It was a sensation among scientists and inspired a flurry of new research into this long-misunderstood gas. Soon after, Yandell Henderson, the director of the Laboratory of Applied Physiology at Yale, began his own set of experiments. Henderson too had spent the last several years studying metabolism, and, like Bohr, he was convinced that carbon dioxide was as essential to the body as any vitamin.

"Although clinicians still find it hard to believe, oxygen is in no sense a stimulant to living creatures," Henderson would write in the *Cyclopedia of Medicine*. "If a fire is supplied with pure oxygen instead of air, it burns with enormously augmented intensity. But when a man or animal breathes oxygen, or [air] enriched with oxygen, no more of that gas is consumed, no more heat is produced and no more carbon dioxide is exhaled than when air alone is breathed."



For a healthy body, overbreathing or inhaling pure oxygen would have no benefit, no effect on oxygen delivery to our tissues and organs, and could actually create a state of oxygen deficiency, leading to relative suffocation. In other words, the pure oxygen a quarterback might huff between plays, or that a jet-lagged traveler might shell out 50 dollars for at an airport "oxygen bar," are of no benefit. Inhaling the gas might increase blood oxygen levels one or two percent, but that oxygen will never make it into our hungry cells. We'll simply breathe it back out.*

To prove his point, over the years Henderson conducted a number of awful experiments on dogs that are about as difficult to read about as Harvold's awful experiments on monkeys.

He placed individual dogs on a table in his laboratory and inserted a tube into their throats, fitting their faces with a rubber mask. At the end of the tube was a hand bellows. The contraption allowed Henderson to control how much air each dog took in and how often. He'd connected the tube from the dogs' throats to a bottle of ether, which would anesthetize them during the course of the experiment. A suite of instruments recorded heart rate, carbon dioxide, oxygen levels, and more.

As Henderson pumped the bellows faster and faster, he watched heart rates of the animals quickly increase from 40 up to 200 or more beats per minute. The dogs would eventually have so much oxygen flowing through their arteries, with so little carbon dioxide to offload it, that

*Henderson discovered, one hundred years ago, that pure oxygen is only useful for those at altitude (where oxygen levels in the air are decreased) or those who are so sick that they cannot retain healthy oxygen saturation levels (above roughly 90 percent) through normal breathing. But even for sick patients, long-term supplemental oxygen can eventually damage the lungs and decrease red blood cell counts, making it harder for the body to pull oxygen from breath in the future.

muscles, tissues, and organs began failing. Some dogs would spasm uncontrollably or drift into a coma. If Henderson kept pumping more air in, the animals became so full of oxygen and so deficient in carbon dioxide that they died.

Henderson killed dogs with their own breath.

With the dogs that survived, he would pump the bellows slower and watch as their heart rates immediately decreased to 40 beats per minute. It wasn't the act of breathing that sped up and slowed the dogs' heart rates; it was the amount of carbon dioxide flowing through the bloodstream.

Henderson then forced the dogs to breathe *just slightly* harder than normal, just above their metabolic needs, so that their heart rates were mildly elevated and carbon dioxide levels a little deficient. This was a condition of mild hyperventilation common in humans.

The dogs grew agitated, confused, anxious, and glassy-eyed. The slight overbreathing was inducing the same confused state that occurred during altitude sickness or panic attacks. Henderson administered morphine and other drugs to slow the animals' heart rates closer to normal. The drugs worked partly because, as Henderson observed, they helped raise carbon dioxide levels.

But there was another way to restore the animals to health: let them breathe slowly. Whenever Henderson lowered the respiratory rate in accordance with the dogs' normal metabolism—from breathing 200 times a minute to a normal rate—all the twitching, stupors, and anxiety went away. The animals stretched out and relaxed, their muscles loosened, and a peacefulness washed over them.

"Carbon dioxide is the chief hormone of the entire body; it is the only one that is produced by every tissue and that probably acts on every organ," Henderson later wrote. "Carbon dioxide is, in fact, a more fundamental component of living matter than is oxygen."



. . .

I spent three days with Olsson in Stockholm. We pored over tables and graphs and talked about Bohr and Henderson and other storied pulmonauts. By the end of my trip, I finally understood how my own view of breathing had been so limited, and so wrong, for so many years. And I finally understood how Olsson had become so obsessed with this line of research, why he'd given up his life as a software tycoon and downgraded to a tiny apartment, surrounded by shelves of biochemistry textbooks, sleep tape, and carbon dioxide tanks. Why he'd spent so many months recording how carbon dioxide levels changed inside his body with each new breathing technique, how it affected his blood pressure and his energy and stress levels.

I understood why only one person showed up for the first conference he held on breathing, in 2010, and why, after honing his message and building his research base, he was now something of a Swedish media star who filled auditoriums, his grinning, perpetually tanned, rom-com face popping up on newspapers, magazines, and nightly news shows. In these interviews, he championed the therapeutic effects of nasal breathing and beseeched audiences with the same message of slow breathing.

I returned home to San Francisco, and Olsson and I kept in contact. Every few weeks I'd get a new email or a Skype call about some new long-lost scientific discovery he'd just unearthed in a medical library. He'd continued his self-experimentation too, always seeking to use his own body to prove the power of breathing and wonders of the "metabolic waste product," carbon dioxide.

This is how Olsson ended up, a year after our first meeting, in my living room in San Francisco with a face mask Velcroed to his head and an EKG electrode clipped to his ear.

* * *

"Could you hand me the oximeter, please?" Olsson says again across the table.

We've just finished our afternoon testing, and Olsson is restrapping himself into the BreathIQ, a prototype of a device that measures carbon dioxide, ammonia, and other elements in the exhaled breath. He clips a pulse oximeter on his finger and starts counting down the seconds.

Maybe it's the carbon dioxide and nitric oxide boost from nasal breathing, but we're feeling punchy today. In addition to the five grand we dropped to take before-and-after X-rays and blood and pulmonary function tests at Stanford, Olsson and I also managed to amass several thousand dollars' worth of equipment at the home lab. We've spent two weeks running tests and have yet to push the throttle on it all. That's changing today.

Olsson wipes a hand on his Abercrombie sweatshirt and scoots over so that I can see the readouts on the machines. All his vitals are normal: heart rate hovers around 75, systolic blood pressure clocks in at 126, oxygen levels at 97 percent. *Three, two, one,* he begins breathing.

But slowly, very slowly. He inhales and exhales three times slower than the average American, turning those 18 breaths a minute into six. As he sips air in through his nose and out through his mouth, I watch as his carbon dioxide levels rise from 5 percent to 6 percent. They keep rising. A minute later, Olsson's levels are 25 percent higher than they were just a few minutes ago, taking him from an unhealthy hypocapnic zone to squarely within a medically normal range. All the while, his blood pressure drops about five points and heart rate sinks to the mid-60s.

What hasn't changed is his oxygen. From start to finish, even though he's been breathing at a third of the rate considered normal, his oxygen hasn't wavered: it stayed at 97 percent.

We'd experienced the same confounding measurements during our



bike workouts earlier in the week. The beginning of those workouts, like all workouts, sucked. We felt our lungs and respiratory system desperately trying to meet the needs of our hungry tissues and muscles: the dinner rush of the body. Normally, I'd open my mouth and huff and puff, trying to sate that nagging need for oxygen. But for the last few days, as I cranked the pedals harder and faster, I forced myself to breathe softer and slower. This felt stifling and claustrophobic, like I was starving my body of fuel, until I checked the pulse oximeter. Once again, no matter how slowly I breathed or how hard I pedaled, my oxygen levels held steady at 97 percent.

It turns out that when breathing at a normal rate, our lungs will absorb only about a quarter of the available oxygen in the air. The majority of that oxygen is exhaled back out. By taking longer breaths, we allow our lungs to soak up more in fewer breaths.

"If, with training and patience, you can perform the same exercise workload with only 14 breaths per minute instead of 47 using conventional techniques, what reason could there be not to do it?" wrote John Douillard, the trainer who'd conducted the stationary bike experiments in the 1990s. "When you see yourself running faster every day, with your breath rate stable . . . you will begin to feel the true meaning of the word *fitness*."

I realized then that breathing was like rowing a boat: taking a zillion short and stilted strokes will get you where you're going, but they pale in comparison to the efficiency and speed of fewer, longer strokes.

On the second day of using this slower, nasal breathing approach, I'd outdistanced my mouthbreathing record by .13 of a mile. The next session, I pedaled .36 miles farther—a 5 percent increase over mouthbreathing. By my fifth ride on the stationary bike, I pedaled 7.7 miles, almost a full mile longer, in the same amount of time, using the same amount of energy, than I had the previous week. This was a significant gain. It wasn't quite yet up to the levels Douillard's cyclists reported, but I was edging closer.

During that ride, I started playing around with my breathing. I tried to inhale and exhale slower and slower, from my usual exercising rate of 20 breaths a minute to just six. I immediately felt a sense of air hunger and claustrophobia. After a minute or so I looked down at the pulse oximeter to see how much oxygen I was losing, how starved my body had become.

But my oxygen hadn't decreased with these very slow breaths, as I or anyone else might expect. My levels *rose*.

. . .

A last word on slow breathing. It goes by another name: prayer.

When Buddhist monks chant their most popular mantra, *Om Mani Padme Hum*, each spoken phrase lasts six seconds, with six seconds to inhale before the chant starts again. The traditional chant of *Om*, the "sacred sound of the universe" used in Jainism and other traditions, takes six seconds to sing, with a pause of about six seconds to inhale.

The *sa ta na ma* chant, one of the best-known techniques in Kundalini yoga, also takes six seconds to vocalize, followed by six seconds to inhale. Then there were the ancient Hindu hand and tongue poses called *mudras*. A technique called *khechari*, intended to help boost physical and spiritual health and overcome disease, involves placing the tongue above the soft palate so that it's pointed toward the nasal cavity. The deep, slow breaths taken during this *khechari* each take six seconds. Japanese, African, Hawaiian, Native American, Buddhist, Taoist, Christian—these cultures and religions all had somehow developed the same prayer techniques, requiring the same breathing patterns. And they all likely benefited from the same calming effect.

In 2001, researchers at the University of Pavia in Italy gathered two dozen subjects, covered them with sensors to measure blood flow, heart



rate, and nervous system feedback, then had them recite a Buddhist mantra as well as the original Latin version of the rosary, the Catholic prayer cycle of the Ave Maria, which is repeated half by a priest and half by the congregation. They were stunned to find that the average number of breaths for each cycle was "almost exactly" identical, just a bit quicker than the pace of the Hindu, Taoist, and Native American prayers: 5.5 breaths a minute.

But what was even more stunning was what breathing like this did to the subjects. Whenever they followed this slow breathing pattern, blood flow to the brain increased and the systems in the body entered a state of coherence, when the functions of heart, circulation, and nervous system are coordinated to peak efficiency. The moment the subjects returned to spontaneous breathing or talking, their hearts would beat a little more erratically, and the integration of these systems would slowly fall apart. A few more slow and relaxed breaths, and it would return again.

A decade after the Pavia tests, two renowned professors and doctors in New York, Patricia Gerbarg and Richard Brown, used the same breathing pattern on patients with anxiety and depression, minus the praying. Some of these patients had trouble breathing slowly, so Gerbarg and Brown recommended they start with an easier rhythm of three-second inhales with at least the same length exhale. As the patients got more comfortable, they breathed in and breathed out longer.

It turned out that the most efficient breathing rhythm occurred when both the length of respirations and total breaths per minute were locked in to a spooky symmetry: 5.5-second inhales followed by 5.5-second exhales, which works out almost exactly to 5.5 breaths a minute. This was the same pattern of the rosary.

The results were profound, even when practiced for just five to ten minutes a day. "I have seen patients transformed by adopting regular breathing practices," said Brown. He and Gerbarg even used this slow breathing technique to restore the lungs of 9/11 survivors who suffered from a chronic and painful cough caused by the debris, a horrendous condition called ground-glass lungs. There was no known cure for this ailment, and yet after just two months, patients achieved a significant improvement by simply learning to practice a few rounds of slow breathing a day.

Gerbarg and Brown would write books and publish several scientific articles about the restorative power of the slow breathing, which would become known as "resonant breathing" or Coherent Breathing. The technique required no real effort, time, or thoughtfulness. And we could do it anywhere, at any time. "It's totally private," wrote Gerbarg. "Nobody knows you're doing it."

In many ways, this resonant breathing offered the same benefits as meditation for people who didn't want to meditate. Or yoga for people who didn't like to get off the couch. It offered the healing touch of prayer for people who weren't religious.

Did it matter if we breathed at a rate of six or five seconds, or were a half second off? It did not, as long as the breaths were in the range of 5.5.

"We believe that the rosary may have partly evolved because it synchronized with the inherent cardiovascular (Mayer) rhythms, and thus gave a feeling of wellbeing, and perhaps an increased responsiveness to the religious message," the Pavia researchers wrote. In other words, the meditations, Ave Marias, and dozens of other prayers that had been developed over the past several thousand years weren't all baseless.

Prayer heals, especially when it's practiced at 5.5 breaths a minute.

Six

# LESS

Few would dispute that we've become a culture of overeaters. From around 1850 to 1960, the American mean body mass index (BMI), a measurement of fat based on height, was between 20 and 22. That's about 160 pounds for a six-foot-tall person. Today, the average BMI is 29, a 38 percent jump in 50 years. That six-foot person now weighs 214 pounds. Seventy percent of the U.S. population is considered overweight; one in three are obese. There's no doubt we are eating more than we did in the past.

Rates of breathing are much more difficult to gauge, because there are fewer studies and the results are inconsistent. Nonetheless, a review of several available studies offers a troubling picture.

What's considered medically normal today is anywhere between a dozen and 20 breaths a minute, with an average intake of about half a