Now, lying here again, no matter how I try to relax and submit to this experiment, it's a challenge. Every 3.3 seconds another blast of unfiltered, unmoistened, and unheated air enters through my mouth—drying my tongue, irritating my throat, and pissing off my lungs. And I've got 175,000 more breaths to go.

Two

MOUTHBREATHING

It's 8:15 a.m., and Olsson bursts in, Kramer-style, through the side door of the downstairs flat I'm in. "Good morning," he shouts. He has little balls of silicone lodged up his nose and is wearing cut-off sweatpants and an Abercrombie & Fitch sweatshirt.

Olsson rented a studio apartment across the street from me for the month, close enough to sneak over wearing his pajamas, but not close enough to avoid looking like a freak doing it. His face, once tan and bright, is now gaunt and sallow, and he looks like Gary Busey in that police mugshot. He has the same spaced-out expression that he had yesterday; the same haunted grin that he wore the day before and the day before that.

Today marks the halfway point of the mouthbreathing phase of the experiment. And today, like every other day, as he's been doing three times a day—morning, noon, and night—Olsson takes a seat across from

me at the table. *One-two-three*, we flip on a pile of beeping and burping machines lumped on the table, strap cuffs to our arms, place EKG sensors on our ears, stick thermometers in our mouths, and begin recording our physiological data on spreadsheets. The data reveal what the previous days have revealed: mouthbreathing is destroying our health.

My blood pressure has spiked by an average of 13 points from where it was before the test, which puts me deep into stage 1 hypertension. If left unchecked, this state of chronically raised blood pressure, also shared by a third of the U.S. population, can cause heart attacks, stroke, and other serious problems. Meanwhile, my heart rate variability, a measure of nervous system balance, has plummeted, suggesting that my body is in a state of stress. Then there's my pulse, which has increased, and my body temperature, which has decreased, and my mental clarity, which has hit rock bottom. Olsson's data mirror mine.

But the worst part about all this is how we *feel*: awful. Every day it all just seems to be getting worse. And every day, at this exact time, Olsson finishes off his last test, removes the respirator mask from his cotton-white hair, stands up, and jams the silicone plugs a little deeper into his nostrils. He puts his sweatshirt back on and says, "I'll meet you at ten-thirty," then walks out the door. I nod and watch as he trots his slippered feet through the hallways and back across the street.

The final testing protocol, eating, happens alone. Through both phases of the experiment, we'll be eating the same food at the same time and continuously recording our blood sugar levels while taking the same amount of steps throughout the day to see how mouthbreathing and nasal breathing might affect weight and metabolism. Today it's three eggs, half an avocado, a piece of German brown bread, and a pot of Lapsang tea. Which means that, ten days from now, I will again be sitting in this kitchen, eating this same meal.

After eating, I do the dishes, clean up used filters, pH strips, and

Post-it notes in the living room laboratory, and answer some emails. Sometimes Olsson and I sit around and experiment with more comfortable and effective ways to keep our noses blocked: waterproof earplugs (too hard), foam earplugs (too soft), a swimmer's nose clip (too painful), a CPAP nose pillow (comfortable, but it looks like a bondage device), toilet paper (too airy), chewing gum (too slimy), and, finally, surgical tape over silicone or foam earplugs, which is chafing and stifling but the least atrocious of the options.

But most of the time, all day, every day, for the past five days, Olsson and I have just sat around alone in our apartments and hated life. I often feel as though I'm trapped in some sad sitcom in which nobody laughs, a Groundhog Day of perpetual and unending misery.

Luckily, today is a little different. Today, Olsson and I are going on a bike ride. Not on a beach boardwalk or in the shadow of the Golden Gate, but inside the concrete walls of a fluorescent-lit neighborhood gym.

The cycling was Olsson's idea. He'd spent about ten years researching the differences in performance between nasal breathers and mouthbreathers during intense exercise. He'd conducted his own studies on CrossFit athletes, and he'd worked with coaches. He'd become convinced that mouthbreathing can put the body into a state of stress that can make us more quickly fatigued and sap athletic performance. He insisted that, for a few days during each phase of the experiment, we saddle up on stationary bikes and pedal to the edge of our aerobic capacity. The plan was to meet at the gym at 10:15 a.m.

I put on some shorts, grab the fitness tracker, an extra set of silicone plugs, a water bottle, and exit through the backyard. Waiting by the fence is Antonio, a contractor and longtime friend who has been doing renovation work on an upper floor of my house. He looks over, and before I

can make a beeline for the garden exit, he notices the pink earplugs in my nose, drops an armful of two-by-fours, and comes over to take a closer look.

I'd known Antonio for 15 years and he'd heard about the oddball stories in far-off places I'd researched in the past. He'd always been interested and supportive. That ended when I tell him about what I've been up to this week.

"This is a bad idea," he says. "In school, when I was young, teachers walked around the classroom, man, and *pop-pop-pop*." He smacks the back of his own head for emphasis. "You're breathing from your mouth, you get *pop*," he says. Mouthbreathing leads to sickness and is disrespectful, he told me, which is why he and everyone else he grew up with in Puebla, Mexico, learned to breathe through the nose.

Antonio told me his partner, Janet, suffers from chronic obstruction and runny nose. Janet's son, Anthony, is also a chronic mouthbreather. He's starting to suffer the same problems. "I keep telling them this is bad, they try to fix it," Antonio said. "But it's hard, man."

I'd heard a similar story from an Indian-British man named David a few days ago, when Olsson and I attempted our first nasal-obstructed jog along the Golden Gate Bridge. David noticed our nasal bandages, stopped us, and asked what we were doing. Then he told us how he'd had obstruction problems all his life. "Always plugged or running, it never seemed to be, you know, open," he said. He'd spent the last 20 years squirting various drugs up his nostrils, but they became less effective over time. Now he'd developed chronic respiratory problems.

To avoid hearing more of these stories and to evade any more unwanted attention, I'd learned to go outside only when I had to. Don't get me wrong: San Franciscans love weirdos. There was once a guy who used to walk Haight Street with a hole in the back of his jeans so that his tail—an *actual* human tail about five inches long—could swing freely behind him. He hardly got second glances.

But the sight of Olsson and me with plugs and tape and whatever else in and around our noses has proven too much for locals to bear. Everywhere we go, we get either questioned or somebody's long life story of breathing woes, how he is congested, how her allergies keep getting worse, how his head hurts and sleep suffers the worse his breathing seems to get.

I wave goodbye to Antonio, pull the visor of the baseball cap a little farther down to hide my plugged face and jog a few blocks to the gym. I make my way around women speedwalking on treadmills and old men on weight machines. I can't help noticing that all of them are mouthbreathing.

Then I boot up the pulse oximeter, set the stop watch, hop on a stationary bike, latch my feet into the pedals, and I'm off.

The bike experiment is a repeat of several studies conducted 20 years earlier by Dr. John Douillard, a trainer to elite athletes, from tennis star Billie Jean King to triathletes to the New Jersey Nets. In the 1990s, Douillard became convinced that mouthbreathing was hurting his clients. To prove it, he gathered a group of professional cyclists, rigged them up with sensors to record their heart rate and breathing rate, and put them on stationary bikes. Over several minutes, Douillard increased the resistance on the pedals, requiring the athletes to exert progressively more energy as the experiment went on.

During the first trial, Douillard told the athletes to breathe entirely through their mouths. As the intensity increased, so did the rate of breathing, which was expected. By the time athletes reached the hardest stage of the test, pedaling out 200 watts of power, they were panting and struggling to catch a breath.

Then Douillard repeated the test while the athletes breathed through their noses. As the intensity of exercise increased during this phase, the rate of breathing *decreased*. At the final, 200-watt stage, one subject who had been mouthbreathing at a rate of 47 breaths per minute was nasal breathing at a rate of 14 breaths a minute. He maintained the same heart

rate at which he'd started the test, even though the intensity of the exercise had increased tenfold.

Simply training yourself to breathe through your nose, Douillard reported, could cut total exertion in half and offer huge gains in endurance. The athletes felt invigorated while nasal breathing rather than exhausted. They all swore off breathing through their mouths ever again.

For the next 30 minutes on the stationary bike, I'll follow Douillard's test protocol, but instead of measuring exertion with weight, I'll use distance. I'll keep my heart rate locked in to a consistent 136 beats per minute while measuring how far I can go with my nose plugged and breathing only from my mouth. Olsson and I will come back here over the next several days, then return next week to repeat the test while breathing only through our noses. This data will provide a general overview of how these two breathing channels affect endurance and energy efficiency.

To understand how breathing affects athletic performance, we first need to understand how the body makes energy from air and food. There are two options: with oxygen, a process known as aerobic respiration, and without it, which is called anaerobic respiration.

Anaerobic energy is generated only with glucose (a simple sugar), and it's quicker and easier for our bodies to access. It's a kind of backup system and turbo boost when the body doesn't have enough oxygen. But anaerobic energy is inefficient and can be toxic, creating an excess of lactic acid. The nausea, muscle weakness, and sweating you experience after you've pushed it too hard at the gym is the feeling of anaerobic overload. This process explains why the first few minutes of an intense workout are often so miserable. Our lungs and respiratory system haven't caught up to supply the oxygen our bodies need, and so the body has to use anaerobic respiration. This also explains why, after we're

warmed up, exercise feels easier. The body has switched from anaerobic to aerobic respiration.

These two energies are made in different muscle fibers throughout the body. Because anaerobic respiration is intended as a backup system, our bodies are built with fewer anaerobic muscle fibers. If we rely on these less-developed muscles too often, they eventually break down. More injuries occur during the post–New Year's rush to gyms than at any other time of the year, because too many people attempt to exercise far over their thresholds. Essentially, anaerobic energy is like a muscle car—it's fast and responsive for quick trips, but polluting and impractical for long hauls.

This is why aerobic respiration is so important. Remember those cells that evolved to eat oxygen 2.5 billion years ago and kicked off an explosion of life? We've got some 37 trillion of them in our bodies. When we run our cells aerobically with oxygen, we gain some 16 times more energy efficiency over anaerobic. The key for exercise, and for the rest of life, is to stay in that energy-efficient, clean-burning, oxygen-eating aerobic zone for the vast majority of time during exercise and at all times during rest.

Back in the gym, I pedal a little harder, breathe a little deeper, and watch as my heart rate increases steadily, from 112 to 114 and on up. Over the next three minutes of warm-up, I need to get to 136 then keep it there for a half hour. This rate should be right at the aerobic/anaerobic threshold for a man my age.

In the 1970s, Phil Maffetone, a top fitness coach who worked with Olympians, ultramarathoners, and triathletes, discovered that most standardized workouts could be more injurious than beneficial to athletes. The reason is that everybody is different, and everybody will react to training. Busting out a hundred pushups may be great for one person but harmful to another. Maffetone personalized his training to focus on the more subjective metric of heart rates, which ensured that his athletes

stayed inside a defined aerobic zone, and that they burned more fat, recovered faster, and came back the next day—and the next year—to do it again.

Finding the best heart rate for exercise is easy: subtract your age from 180. The result is the maximum your body can withstand to stay in the aerobic state. Long bouts of training and exercise can happen below this rate but never above it, otherwise the body will risk going too deep into the anaerobic zone for too long. Instead of feeling invigorated and strong after a workout, you'd feel tired, shaky, and nauseated.

Which is basically what happens to me. After I do a half hour of vigorous pedaling and openmouthed huffing, the clock on the stationary bike ticks down to zero and the whirling gears slow to a stop. I'm sweating profusely and feel bleary-eyed, but I've pedaled a total of only 6.44 miles. I scoot off the bike and let Olsson take a spin, then it's back to the home lab for a shower, a glass of water, and more testing.

* * *

Decades before Olsson and I jammed our noses shut, and before Douillard put his cyclists through the rounds, scientists were running their own tests on the pros and cons of mouthbreathing.

There was Austen Young, an enterprising doctor in England who, in the 1960s, treated a slew of chronic nose-bleeders by sewing their nostrils shut. One of Young's followers, Valerie J. Lund, revived the procedure in the 1990s and stitched the nostrils of dozens of patients. I repeatedly tried to contact Lund to ask how her mouthbreathing patients fared after weeks, months, and years, but never got a reply. Luckily, those consequences were spelled out by a Norwegian-American orthodontist and researcher chasing very different ends.

Egil P. Harvold's hideous experiments in the 1970s and 80s would not go over well with PETA or with anyone who has ever really cared for

animals. Working from a lab in San Francisco, he gathered a troop of rhesus monkeys and stuffed silicone deep into the nasal cavities of half of them, leaving the other half as they were. The obstructed animals couldn't remove the plugs, and they couldn't breathe at all through their noses. They were forced to adapt to constant mouthbreathing.

Over the next six months, Harvold measured the animals' dental arches, the angles of their chins, the length of their faces, and more. The plugged-up monkeys developed the same downward growth pattern, the same narrowing of the dental arch, crooked teeth, and gaping mouth. Harvold repeated these experiments, keeping animals obstructed for two years. They fared even worse. Along the way, he took a lot of pictures.

The photographs are heart-wrenching, not only for the sake of the poor monkeys, but because they also offer such a clear reflection of what happens to our own species: after just a few months, faces grew long, slack-jawed, and glazed over.

Mouthbreathing, it turns out, changes the physical body and transforms airways, all for the worse. Inhaling air through the mouth decreases pressure, which causes the soft tissues in the back of the mouth to become loose and flex inward, creating less overall space and making breathing more difficult. Mouthbreathing begets more mouthbreathing.

Inhaling from the nose has the opposite effect. It forces air against all those flabby tissues at the back of the throat, making the airways wider and breathing easier. After a while, these tissues and muscles get "toned" to stay in this opened and wide position. Nasal breathing begets more nasal breathing.

"Whatever happens to the nose affects what's happening in the mouth, the airways, the lungs," said Patrick McKeown during a phone interview. He's a bestselling Irish author and one of the world's leading experts on nasal breathing. "These aren't separate things that operate autonomously—it's one united airway," he told me.

None of this should come as a surprise. When seasonal allergies hit, incidences of sleep apnea and breathing difficulties shoot up. The nose gets stuffed, we start mouthbreathing, and the airways collapse. "It's simple physics," McKeown told me.

Sleeping with an open mouth exacerbates these problems. Whenever we put our heads on a pillow, gravity pulls the soft tissues in the throat and tongue down, closing off the airway even more. After a while, our airways get conditioned to this position; snoring and sleep apnea become the new normal.

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It's the last night of the nasal obstruction phase of the experiment, and I am, again, sitting up in bed and staring out the window.

When a Pacific breeze blows in, which it does most nights, the shadows of the trees and plants on the backyard wall across from my bedroom start to move and groove in a chromatic kaleidoscope. One moment they reorganize into a cadre of Edward Gorey gentlemen in waistcoats, the next into crooked Escher staircases. Another gust of wind, and these scenes disintegrate and reform into recognizable stuff: ferns, bamboo leaves, bougainvillea.

This is a long way of saying: I can't sleep. My head's been propped up on pillows and I've been taking notes on this creepy tableau for 15, 20, maybe 40 minutes. I unconsciously try to sniff and clear my nose, but instead get a jolt of pain in my head. It's a sinus headache, and in my case, self-inflicted.

Each night for the past week and a half, I've felt as if I was getting softly choked to death in my sleep and my throat was closing in on itself. Because it is, and because I am. Forced mouthbreathing was very likely changing the shape of my airways, just as it did with Harvold's monkeys.

The changes weren't happening in a matter of months, either, but days. It was getting worse with every breath I took.

My snoring has increased 4,820 percent from ten days ago. For the first time that I'm aware of, I'm beginning to suffer from obstructive sleep apnea. At my worst, I've averaged 25 "apnea events," meaning I was choking so severely that my oxygen levels dropped to below 85 percent.

Whenever oxygen falls below 90 percent, the blood can't carry enough of it to support body tissues. If this goes on too long, it can lead to heart failure, depression, memory problems, and early death. My snoring and sleep apnea are still far below that of any medically diagnosed condition, but these scores were getting worse the longer I stayed plugged up.

Every morning Olsson and I would listen to recordings of ourselves sleeping the night before. We laughed at first, then we got a bit frightened: what we heard weren't the sounds of happy Dickensian drunks, but of men being strangled to death by our own bodies.

"More wholesome to sleep . . . with the mouth shut," wrote Levinus Lemnius, a Dutch physician from the 1500s who was credited as one of the first researchers to study snoring. Even back then, Levinus knew how injurious obstructive breathing during sleep could be. "For they that sleep with their Jaws extended, by reason of their breath, and the air tossed to and fro, have their tongues and palates dry, and desire to be moistened by drinking in the night."

This was another thing that kept happening to me. Mouthbreathing causes the body to lose 40 percent more water. I felt this all night, every night, waking up constantly parched and dry. You'd think this moisture loss would decrease the need to urinate, but, oddly, the opposite was true.

During the deepest, most restful stages of sleep, the pituitary gland, a pea-size ball at the base of the brain, secretes hormones that control the release of adrenaline, endorphins, growth hormone, and other

substances, including vasopressin, which communicates with cells to store more water. This is how animals can sleep through the night without feeling thirsty or needing to relieve themselves.

But if the body has inadequate time in deep sleep, as it does when it experiences chronic sleep apnea, vasopressin won't be secreted normally. The kidneys will release water, which triggers the need to urinate and signals to our brains that we should consume more liquid. We get thirsty, and we need to pee more. A lack of vasopressin explains not only my own irritable bladder but the constant, seemingly unquenchable thirst I have every night.

There are several books that describe the horrendous health effects of snoring and sleep apnea. They explain how these afflictions lead to bed-wetting, attention deficit hyperactivity disorder (ADHD), diabetes, high blood pressure, cancer, and so on. I'd read a report from the Mayo Clinic which found that chronic insomnia, long assumed to be a psychological problem, is often a breathing problem. The millions of Americans who have a chronic insomnia disorder and who are, right now, like me, staring out bedroom windows, or at TVs, phones, or ceilings, can't sleep because they can't breathe.

And contrary to what most of us might think, no amount of snoring is normal, and no amount of sleep apnea comes without risks of serious health effects. Dr. Christian Guilleminault, a sleep researcher at Stanford, found that children who experienced no apnea events at all—only heavy breathing and light snoring, or "increased respiratory effort"—could suffer from mood disorders, blood pressure derangements, learning disabilities, and more.

Mouthbreathing was also making me dumber. A recent Japanese study showed that rats who had their nostrils obstructed and were forced to breathe through their mouths developed fewer brain cells and took twice as long to make their way through a maze than nasal-breathing controls. Another Japanese study in humans from 2013 found that

mouthbreathing delivered a disturbance of oxygen to the prefrontal cortex, the area of the brain associated with ADHD. Nasal breathing had no such effects.

The ancient Chinese were onto it as well. "The breath inhaled through the mouth is called 'Ni Ch'i, adverse breath,' which is extremely harmful," states a passage from the Tao. "Be careful not to have the breath inhaled through the mouth."

As I lie in bed tossing and turning, fighting the urge to run to the bathroom again, I'm trying to focus on the positive, and am reminded of a skull from Marianna Evans's collection that offered a much-needed dose of hope.

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It was morning, and Evans was seated in front of an oversize computer monitor in the administrative office of her orthodontics practice, about a half hour west of downtown Philadelphia. With white walls and white-tiled floors, the place looked futuristic. It was the opposite of the tan-stucco strip-mall blocks with ferns, goldfish tanks, and Robert Doisneau prints of all the dental offices I'd been to. Evans, I learned, ran a different kind of practice.

She brought up two images on a computer monitor, one of an ancient skull from the Morton Collection, and the other of a young girl, a new patient. I'll call her Gigi. Gigi was about seven in the photo. Her teeth jutted from the top of her gums, outward, inward, and in all directions. There were dark circles under her eyes; her lips were chapped and open as if she were sucking on an imaginary Popsicle. She suffered from chronic snoring, sinusitis, and asthma. She'd just started developing allergies to foods, dust, and pets.

Gigi grew up in a wealthy household. She followed the Food Guide Pyramid, got plenty of outdoor exercise, had her immunizations, took

vitamins D and C, and had no illnesses growing up. And yet, here she was. "I see patients like this all day," said Evans. "They are all the same."

And here we are. Ninety percent of children have acquired some degree of deformity in their mouths and noses. Forty-five percent of adults snore occasionally, and a quarter of the population snores constantly. Twenty-five percent of American adults over 30 choke on themselves because of sleep apnea; and an estimated 80 percent of moderate or severe cases are undiagnosed. Meanwhile, the majority of the population suffers from some form of breathing difficulty or resistance.

We've found ways to clean up our cities and to tame or kill off so many of the diseases that destroyed our ancestors. We've become more literate, taller, and stronger. On average, we live three times longer than people in the Industrial Age. There are now seven and a half billion humans on the planet—a thousand times more people than there were 10,000 years ago.

And yet we've lost touch with our most basic and important biological function.

Evans painted a depressing picture. And the irony wasn't lost on me as I sat in a sparkling clinic looking at one modern face after another and comparing them with the ideal form and perfect teeth of Samuel Morton's specimens, which he derided as "Australians and degraded Hottentots." At one point I scooted closer and saw my reflection in the monitor glass—that mangle of disjointed bones, the sloping jaw, stuffy nose, and mouth too small to fit all its teeth. *You fools,* I imagined that ancient skull saying. And for a moment, I swear, it looked like it was laughing.

But Evans hadn't invited me to see her research just to lament the present; her obsession with tracing the decline of human breathing is just a starting point. She'd studied it for years, entirely at her own expense, because she wants to help. She and her colleague, Kevin Boyd, are using the hundreds of measurements they've taken from ancient skulls to build a new model of airway health for modern humans. They are part of a

burgeoning group of pulmonauts exploring novel therapies in breathing, lung expansion, orthodontics, and airway development. Their goal is to help return Gigi, me, and everyone else to our more perfect, ancient forms—the way we were before it all went haywire.

On the computer screen, Evans pulled up another photo. It was Gigi again, but in this shot there were no dark circles, none of the sallow skin or drooping lids. Her teeth were straight and her face was broad and glowing. She was nasal breathing again and no longer snored. Her allergies and other respiratory problems had all but disappeared. The photograph was taken two years after the first, and Gigi looked transformed.

The same thing happened with other patients—both adults and children—who'd regained the ability to breathe properly: their slack-jawed and narrowed faces morphed back into a more natural configuration. They saw their high blood pressure drop, depression abate, headaches disappear.

Harvold's monkeys recovered, too. After two years of forced mouthbreathing, he removed the silicone plugs. Slowly, surely, the animals relearned how to breathe through their noses. And slowly, surely, their faces and airways remodeled: jaws moved forward and facial structure and airways morphed back into their wide and natural state.

Six months after the experiment ended, the monkeys looked like monkeys again, because they were breathing normally again.

Back in my bedroom, staring out at the shadow play of branches in the window, I'm hoping that I too can reverse whatever damage I'd done in the last ten days, and the past four decades. I'm hoping I can relearn to breathe the way my ancestors breathed. I suppose I'll see soon enough.

Tomorrow morning, the plugs come out.