

*The Best American Science
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*Edited and with an Introduction
by Siddhartha Mukherjee*

Tim Folger, Series Editor



A Mariner Original

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Foreword

ON AN AUTUMN night 404 years ago, a struggling mathematics professor at the University of Padua aimed a crude, three-foot-long wood and leather telescope at the night sky. Galileo Galilei didn't invent the telescope; a trio of Dutch eyeglass makers had done that a year before Galileo used one to observe the sky over Tuscany. Nor was he the first to turn a telescope toward the heavens—an Englishman named Thomas Harriot, who sketched the moon in July 1609, claimed that honor. But Galileo was the first to truly *see* what the heavens held.

Unlike Harriot, whose drawings depicted the moon as two-dimensional, Galileo, who had had formal training as an artist, understood that the moon was not flat and smooth. By carefully studying the nightly changes in light and shadow on the lunar surface, Galileo realized that the moon had valleys, mountains, and plains not wholly unlike those on Earth. His remarkable sketches of the moon, published in 1610 in a pamphlet called *Sidereus Nuncius*, or “Starry Messenger,” showed a full-fledged world, pocked and imperfect. It was just one of many observations that contradicted centuries of dogma, which held the heavens to be unchanging and perfect, composed of a rarefied celestial element, quintessence, with the planets and stars embedded on a series of concentric invisible spheres. The booklet sold out within months of publication. Its forty pages also recounted Galileo's discovery that Jupiter had four moons of its own, which completely overturned the notion that every object in the heavens orbited Earth. And the Milky Way was not the diffuse cloud it appeared to be but rather, in Galileo's words, “a congeries of innumerable stars.”

Not everyone welcomed—or even recognized—Galileo's revelations. One critic, an astrologer named Francesco Sizzi, argued that the moons of Jupiter didn't really exist, because “the satellites are invisible to the naked eye.” Even some who looked through telescopes and saw the moon's imperfect surface refused to discard their old beliefs. Lodovico delle Colombe, a Florentine philosopher, argued that a perfect invisible sphere surrounded the moon. Galileo countered that perhaps the invisible sphere had invisible mountains as well.

The failure to acknowledge or understand the discoveries of science was not unique to Galileo's time. We have our own Sizzis and Delle Colombes today: politicians who deny the existence of global warming, even as glaciers shrink in Greenland and ice disappears from the Arctic (see Keith Gessen's “Polar Express” for more on the state of the Arctic), and advocates of creationism, who would see pseudoscience taught in the nation's schools, 164 years after the publication of Darwin's *On the Origin of Species*. Fortunately, we have many gifted writers—call them starry messengers—who gracefully communicate the most important stories of our time. Some of those writers, like Siddharta Mukherjee, our guest editor, are scientists themselves, and they give us all an opportunity to peer through a lens, as it were, and see the world as it is, and not as we believe it to be.

When we do gaze through that lens, we often find a world far more beautiful and strange than anything dreamt of by medieval philosophers. Surely not even Galileo could have anticipated the paradoxes of quantum mechanics. In “Beyond the Quantum Horizon,” two eminent physicists discuss, among other things, the meaning of the most confoundingly weird theory in the history of science. Nearly a century after the birth of quantum mechanics, physicists still can't agree on what it says about the nature of reality.

What would Galileo find most astounding about our time? Perhaps it would be the discovery of the enormous scale of the universe, and that it is expanding, which would have been problematic indeed for all those crystalline spheres that were once thought to hold the stars and planets. (See Alan Lightman's “Our Place in the Universe” for a lively history of the evolution of our understanding of the size of the universe.) No doubt he would marvel at our ability to live beneath the sea for days on

end, as the pioneering oceanographer Sylvia Earle has. In “The Sweet Spot in Time,” she shares a lifetime of insights gleaned from more than 7,000 hours underwater—nearly a year altogether. Despite all that we have inflicted on the oceans, her story in these pages shows that she still thrills to the sheer wonder of our existence on a planet unlike any other in the cosmos.

I hope this short overview whets your appetite. Siddhartha Mukherjee has selected twenty-seven stories for this collection. They’re all compelling and wonderful, but I think his lyrical introduction is itself worth the price of admission. You won’t soon forget it. So if I were you, I’d skip ahead right now and be prepared, as some of Galileo’s contemporaries were not, to behold a field of stars.

I hope too that readers, writers, and editors will nominate their favorite articles for next year’s anthology at <http://timfolger.net/forums>. The criteria for submissions and deadlines, and the address to which entries should be sent, can be found in the “news and announcements” forum on my website. Once again this year I’m offering an incentive to enlist readers to scour the nation in search of good science and nature writing: send me an article that I haven’t found, and if the article makes it into the anthology, I’ll mail you a free copy of next year’s edition. Perhaps I’ll manage to cajole Dr. Mukherjee into signing some copies. I also encourage readers to use the forums to leave feedback about the collection and to discuss all things scientific. The best way for publications to guarantee that their articles are considered for inclusion in the anthology is to place me on their subscription list, using the address posted in the “news and announcements” forum. Bribes and other inducements are, I’m afraid, frowned upon.

One of the pleasures of my involvement with this anthology is the opportunity to work with today’s best writers. Dr. Mukherjee’s book *The Emperor of All Maladies: A Biography of Cancer* should be at the top of many reading lists. Once again this year I’m indebted to Ashley Gilliam at Houghton Mifflin Harcourt. This year’s anthology is dedicated to the memory of my mother, Veronica. And as always, I’m grateful to my beautiful muse, Anne Nolan, and to her pals, M. and WFB.

TIM FOLGER

Introduction: On Tenderness

IN THE SUMMER of 2012, I traveled to Brno, in the Czech Republic, to visit the monastery of Gregor Mendel. I knew the barest details of Mendel's life—enough to generate an anatomical sketch but not much more. Originally from a farming family in Moravia, he had joined the Augustinian monastery in Brno in the 1830s. In 1864, working with peas in the garden of his monastery, he stumbled on arguably the most seminal discovery of modern biology: that hereditary information is transmitted from one generation to the next in the form of discrete particles of information—"genes."

The evening train from Vienna to Brno sliced its way through a spectacular landscape of farmland and vineyards—one scintilla of green blending into another. Brno was a small town with an outsize train station. Formerly a major center of commerce, as the guidebook reminded me, protesting feebly it had by now largely resigned itself to its fate as a way station between Vienna and Prague. In the lobby of the hotel, the concierge looked at me quizzically when I asked him about Mendel. Most of the other residents of the hotel were Russians attending a conference on oil manufacturing.

The next morning, I walked about a mile downhill from the hotel to the monastery. The building—St. Thomas's Abbey—is a plaster-and-concrete structure attached to the southern edge of an imposing church. It is as cold as a meat locker and as sparse as a prison. A faded poster of Mendel smiling mysteriously, like a rotund Mona Lisa, hangs on the edge of the boundary walls.

The walled garden in front of the abbey was overgrown and empty. The glass hothouse, where Mendel had artificially pollinated flowers with tiny forceps and a paintbrush, had been dismantled several years earlier. The rectangular plot of land next to the building—a 12-by-6-foot mini-garden where Mendel had grown his peas for his famous experiment—was now planted, incongruously, with rows of red and white gardenias.

An auburn-haired woman was at the front desk.

I told her that I had traveled from New York to Brno to visit Mendel's monastery. "I am a geneticist," I explained, and this was a pilgrimage of sorts. Might I visit the interior of the abbey? Were Mendel's notebooks kept inside? Could I visit the room where he had tabulated his first pea hybrids or the library where he had encountered a copy of Darwin's *On the Origin of Species*?

She looked unconvinced. Apparently the abbey was closed that day. "To enter, you must send in an application," she said in Czech, and then in halting English that I could barely understand. "In duplicate."

"But I am in town for only a single night. I'm sorry, I had no idea about the application," I pleaded.

She shrugged her shoulders. "You must send in an application," she said again, with an air of finality.

My desperation was mounting. "To whom must I apply?" I asked.

"To me," she said.

I scrutinized her face. If there was even the faintest glimmer of irony, I had missed it. Well, two could play this game, I thought.

"In that case, I am applying to you now," I said. "I hereby present my application to visit Gregor Mendel's monastery." I restrained myself from executing a small bow.

The woman considered the impasse carefully. A moment of understanding passed between us, like a tiny, malevolent bolt of electricity. She looked defeated.

"No photographs, okay?" she said. She pulled out a large key from under her desk and escorted me in.

The walls inside were damp. The one-room cells that had housed the monks were largely bare, save a

bed and a wooden desk. The library had about two hundred leather-bound books and a reading chair; scanning it quickly, I found nothing on botany or biology, and certainly no copy of Darwin. Mendel's room, above the refectory, was also bare, with a bed and a chair in the corner. A single evocative moment passed quickly: the wind blew the window open, and, for a second, the room became a microscope or an observatory, revealing a direct view of the rectangular garden plot below.

We made our way down a broad staircase and past the refectory. Downstairs, an inner garden was meant to grow hawkweed—another of Mendel's experimental plants—but was mostly colonized by a tangle of assorted weeds. There was a courtyard, an alleyway into the neighboring church, and a decaying niche for offering prayers. And then, as abruptly as it had started, the visit came to an end.

"Thank you for visiting the abbey," the woman said stiffly, ushering me out the door and locking it with the key.

Back in the lobby, I bought a booklet on Mendel and a T-shirt with his handwritten diagrams reproduced across it. His actual notebooks were housed elsewhere; to access them, I would need another application, possibly in triplicate.

I gave up. As I left the building, sensing the custodian's eyes scanning my back, I wondered whether the fuss had been worth it. As pilgrimages go, this had turned out to be a spectacular anticlimax.

On the train back to Vienna the next morning, I stewed in my seat, ruminating on how disappointing my visit had been. Perhaps I had expected too much. I had gone to Brno seeking something magical: an insight into the *soul* of the man who had revolutionized biology, a reconnaissance with my own intellectual history—a vivid teleportation into Mendel's life and times. But the experience had left me cold and uninspired. I felt duped. I had traveled 3,000 miles to the birthplace of genetics, and all I had gotten was a booklet and a T-shirt.

An hour out of Bratislava, though, my anger cooled. Perhaps the custodians of Mendel's legacy had—if unwittingly—achieved a rather accurate re-creation, or even a reenactment, of his life in the abbey. The rule-boundedness, the deference to authority, the *moral* disapproval at the smallest transgressions of discipline—that ever-so-slight shrug at my unfiled application—were all symptomatic; had Mendel himself been asked to curate a monument to his own stifling times, he could not have chosen a more seasoned actor to play its guardian.

Mendel's forty-odd-year stint at the Brno abbey was, indeed, deeply constrained by rules, habits, and limits. He began his experiments on inheritance by breeding field mice but was asked to discontinue them because forcing mice to mate was considered too risqué for a monk. He failed his training exams in science—notably in geology and biology—because he was unable to classify rocks and mammals using the elaborate traditional systems of classification. A sympathetic superior, Abbot Napp, allowed him to continue his experiments on peas in his garden plot, but Mendel was held to the abbey's strict routines and demands. In one of the few letters that survive, a stern note from his watchers instructs him to remember to wear his cap to church services. Mendel, for his part, was all too eager to comply. Far from a boundary-breaking, rule-bending enfant terrible, he was disciplined, deferential, and dull.

How on earth, then, did *this* man, in *this* place, unlock the secret of genes? Newton had his cometary intellect; Einstein was born a rebel and bred to defy convention; Feynman was the comic genius of physics, exposing his discipline's vanities like a jester in a court of fools. But Gregor Mendel? The founder of modern biology seems, in contrast, to have been born without contrast—a man of habits plodding his way among men in habits.

At least part of the answer, I think, takes us back to the monastery—to that minuscule rectangle of land by the refectory; to the walled garden; to the indelible image of a monk in wire-rimmed glasses

tending plants—stooping, with paintbrush and forceps, to transfer the orange dust of pollen from the stamen of one flower to the pistil of the next. “It requires indeed some courage to undertake a labor of such far-reaching extent,” Mendel wrote in his 1865 paper, describing an eight-year experiment on cross-fertilization that ultimately revealed the existence of genes. But “courage,” I would argue, is the wrong word here. More than “courage,” there is something else evident in that work—a quality that I can only describe as “tenderness.”

It is a word not typically used to describe science or scientists. It shares roots, of course, with “tending”—a farmer’s or gardener’s activity—but also with “tension,” the stretching of a pea tendril to incline it toward sunlight or train it on an arbor. It describes a certain intimacy between humans and nature—a nourishment that must happen before investigation can happen, the delicacy of labor that must be performed before the delicacy of its fruits can be harvested.

Mendel was, first and foremost, a gardener; his science began with tending. His genius was certainly not fueled by deep knowledge of the conventions of biology (thankfully, he failed that exam). Rather, it was his instinctual knowledge of the garden, coupled with an incisive power of observation, that brought him to question the nature of inheritance and thereby discover genes. The act of tending—the laborious cross-pollination of seedlings, the meticulous tabulation of the colors of cotyledons and the markings of wrinkles on seeds—soon led him to findings that could not be explained by the traditional understanding of inheritance. Heredity, Mendel realized, could be explained only by the passage of discrete pieces of information from parents to offspring. There had to be atoms of information—*particles* of inheritance—moving from one generation to the next. Tending generated tension—until the old fulcrum of biology was snapped in two.

When I witness science in action, I see this tenderness in abundance. On Monday mornings, the graduate students and postdoctoral researchers in my laboratory rush in to work to look at how their cells have grown over the weekend. The best of these researchers have a gardener’s instinct. Some of the cultures need nourishment, they know; others, like ferns, need to be left alone to inhabit the corners of incubators; yet others must be coaxed with growth factors to flourish.

Look closely among scientists, and you find this quality everywhere. There is tenderness in the chemist measuring and remeasuring salts in the hood; in the mathematician kneading his equations to understand the shape of the cosmos; in the marine biologist learning to talk to dolphins (read Tim Zimmermann’s “Talk to Me”). Newspapers may bring us news of a scientific-industrial complex that is increasingly depersonalized—algorithmic, disembodied, and run by robots. The lab is apparently a factory. Terabytes of data are churned through supercomputers to generate gigabytes of information; the scientist punches numbers into a machine and awaits revelation. But ask a real scientist, and you get a profoundly different image of how “real” science happens. In an age of increasingly mechanized production, the genesis of scientific knowledge remains an unyieldingly, obstreperously hand-hewn process. It is among the most human of our activities. Far from being subsumed by the dehumanizing effects of technology, science remains our last stand against it.

I have chosen the essays in this volume with an ear for tenderness. Most of the selected essays share a common thread: they describe how science *happens*. They don’t present facts alone (although facts are abundant in them). They describe the extraordinary process by which scientists extract those facts from the grim soil, roots and tendrils intact, to glean knowledge about the inner workings of nature.

Listen, then, for tenderness in these essays. It is present, of course, in Katherine Harmon’s sprawling Russian novel of a piece, “The Patient Scientist,” about a prominent New York immunologist with pancreatic cancer who becomes his own experimental subject (I knew Ralph Steinman, the scientist in question, and was struck by Harmon’s devastatingly honest and moving portrait of him). And it can be found equally in Jerome Groopman’s “The T-Cell Army,” about the

once-moribund discipline of cancer immunology coming to life in the laboratory and the clinic.

It is easy to find tenderness in the remarkable essay “Autism Inc.,” about the parent of an autistic child who starts a company called Specialisterne, Danish for “the specialists”—“on the theory that given the right environment, an autistic adult could not just hold down a job but also be the best person for it.” It may be harder to discern tenderness in Kevin Dutton’s coldly wise “The Wisdom of Psychopaths”—but it’s there, roiling just beneath the surface of this story of a psychologist who seeks to understand the workings of a psychopath’s mind. In talking to dozens of patients confined to a high security psychiatric prison in England, Dutton emerges with a strangely complex understanding of what psychopathy is and how it defines its obverse: empathy.

Steve Weinberg’s “The Crisis of Big Science” is a cry from the heart that is meant to provoke political action. Sometime in the next decade, Weinberg writes, physicists are going to ask their governments to fund the building of the most powerful linear accelerator ever built. This accelerator—not the Large Hadron Collider but the Even Larger Hadron Collider—will supposedly smash its way through an experimental impasse that particle physicists apparently find themselves stuck in, allowing them to prove or disprove models about the fundamental nature of matter and energy. But notably, Weinberg doesn’t confuse big science with great science. His essay begins with a description of Ernest Rutherford’s discovery of the atomic organization of matter. Rutherford’s experimental team, Weinberg informs us, “consisted of one postdoc and one undergraduate,” and was funded by a grant of £70 from the Royal Society. Rutherford worked largely alone, fussing over his instruments and detectors; he was Mendel in an atomic garden. The particle physicists of tomorrow might indeed need bigger accelerators, as Weinberg argues. But to transform big science into great science, I suspect, they will need to channel Rutherford’s spirit into their much larger atomic gardens.

One set of essays describes the measurement, reconstruction, and surveillance or restoration of impossibly fragile systems (read David Owen’s “The Artificial Leaf,” Michael Specter’s “The Deadliest Virus,” David Quammen’s “Out of the Wild,” Mark Bowden’s “The Measured Man,” or Elizabeth Kolbert’s “Recall of the Wild”). Robert M. Sapolsky’s “Super Humanity” and Stephen Marche’s “Is Facebook Making Us Lonely?” converge on a similar and deeply affecting thought—the humans may have created modern environments (including virtual environments) that are peculiarly maladapted for their intended purpose: rather than assuaging anxiety and bringing communities together, these environments provoke anxiety and encourage lonesomeness. Sapolsky’s answer to this quandary is particularly potent: far from rejecting science as dehumanizing, he turns to it as a force of creative regeneration. To tend the wounds of the human psyche—to restore what has been lost—he argues, we need more science, not less.

And look for tenderness, lastly, in “Shattered Genius,” a profile of the Russian mathematician Grigori Perelman, who solved the infamously thorny Poincaré’s Conjecture but could not be bothered with collecting the million-dollar prize for doing so. Perelman is a purist. He despises the crassness of the world, with its academic competitions and silly prizes; he will not be put up for display like an animal in a zoo. There is something raw about him—a hothouse temperament so delicate that the world bruises it all too easily (the profile reminded me of Marianne Moore’s lines on the student, who is reclusive “not because he/has no feeling, but because he has so much”). When an all-too-eager journalist hunts him down to talk about his uncollected prize, Perelman snaps at him with a sentence that a gardener might be proud of: “You are disturbing me. I am picking mushrooms.”

SIDDHARTHA MUKHERJEE

False Idyll

FROM *Orion*

OF ALL THE feelings said to sweep over us in wild places—awe, peace, a sense of the divine—there are a few that rarely get mentioned. My last two-week trip into the woods, for example, was frankly depressing. The year had been a cold one, and the forest was not its usual refulgent self. A black bear was hanging around, skinny and sickly from the bad berry crop and probably bound for death by starvation in its winter den. Pink salmon had just begun to spawn in a nearby creek, where their battered bodies were a reminder of the grand cycle of life, yes, but were also an intimately dismal spectacle. Then I discovered a colony of bats, the year's pups just learning to fly. Not a lot is known about the mortality rate of bats in this fledgling period, but I am inclined to predict it is high. The little ones peeped fearfully before their maiden flights, and with good reason—I watched several crash into the tall grass, unlikely ever to make it home again. They might, at least, make easy meals for the garter snake I saw that had somehow lost half its face.

All of this took place in a valley that, blessed with steep slopes, icy winters, wet summers, and remoteness from the world's stock exchanges, has somehow retained the full complement of predators, including wolves, grizzly bears, and mountain lions. I do indeed feel awe in that place, but not much peace. By day I carry pepper spray, and by night I sleep with a twelve-gauge shotgun close at hand, because a couple of years ago a bear tried to break into my "cabin"—a ninety-year-old homestead shack that can't even keep out the rain—in the first light of dawn. If a god is in charge of the area, he is surely of the mercurial, Old Testament variety.

The idea that nature is a bittersweet and sometimes forbidding place is not, as they say, currently trending. More prevalent is the view reflected in a recent caution from the *Chicago Manual of Style* editors that capital-N "Nature" is to be used only to denote "a goddess dressed in a flowing garment and flinging fruit and flowers everywhere." The comment is tongue-in-cheek, but the point is well taken. The natural world is increasingly seen as a gentle and giving realm of the spirit. In some cases this view is actively religious or quasireligious, whether we are speaking of the biosphere as the provident Earth Mother, the being-of-beings that is James Lovelock's Gaia, or simply the handiwork of one or another god. But above all else, the actual experience of being in nature seems to affirm its essential holiness. The natural world *feels* like a spiritual respite: a literal sanctum, where we are safe to reconnect to what is larger than ourselves. Compared to the cosmic rhythms of mountain, sea, and sky, it is ordinary daily life—driving at rush hour, punching security codes, navigating a shape-shifting digital culture—that seems hostile.

Yet there is a serious problem with our idea of sacred nature, and that is that the idol is a false one. If we experience the natural world as a place of succor and comfort, it is in large part because we have made it so. Only 20 percent of Earth's terrestrial surface is still home to all the large mammals it held five hundred years ago, and even across those refugia they are drastically reduced in abundance. The seas have lost an estimated 90 percent of their biggest fish. For decades there were almost no wolves, grizzly bears, or even bald eagles in the lower forty-eight, and modern recovery projects have brought them back to only a small fraction of their former ranges. Scientists speak of an "ecology of fear" that once guided the movements and behavior of animals that shared land- and seascapes with toothy predators—an anxiety that humans once shared. In much of what's left of the wild, that dread no longer applies even to deer or rabbits, let alone us. The sheer abundance and variety of the living

world, its endless chaos of killing and starving and rutting and suffering, its routine horrors of mass death and infanticide and parasites and drought, have faded from sight and mind. We have rendered nature an easy god to worship.

If humankind's relationship to the wild were to be embodied by just one of the gods we have invented, I would nominate Janus, the twin-faced deity of the ancient Romans. Our sense of the divine can connect us to nature, but it can divide us from it as well. Spirituality can help us see ourselves as kindred to every living and nonliving thing, all sprung from the same celestial dust. This primeval understanding remains deep and broad today, revealed everywhere from the Garden of Eden story shared in one form or another by Christians, Jews, and Muslims; to the Tibetan name for Mount Everest, Chomolungma, the Holy Mother; to \$2,995 shamanic journeys of reconnection to Mother Earth in Sedona, Arizona, complete with one-night vision quests, "weather permitting." On the other hand, spirituality has long been used to place ourselves on a pedestal above the rest of creation. The Garden of Eden story includes instructions to "fill the earth and subdue it" and to "have dominion" over every living thing, among other phrases that amount to a mission statement for latter-day capitalism; Mount Everest is a challenge to be conquered; and that same Arizona wilderness retreat promises to refresh the "natural power that is your birthright."

Old Janus has been staring in these opposite directions a long time—the tension between being a part of nature and standing apart from it is elemental to what it means to be human. "The archaeological record encodes hundreds of situations in which societies were able to develop long-term sustainable relationships with their environments, and thousands of situations in which the relationships were short-lived and mutually destructive," wrote the Arizona State University anthropologist Charles Redman in his seminal 1999 book *Human Impact on Ancient Environments*. The pattern Redman points to is not, as some might suppose, divided neatly between destructive societies in the lineage of so-called Western civilization and sustainable societies in the more earth-toned traditions often associated with, for example, Native Americans. A recent scientific review of human impacts on the oceans found "overwhelming" evidence that aboriginal coastal cultures "often depleted their local environments; in fact, the editors speculate that it may have been the struggle to survive in increasingly degraded surroundings that gave rise to the conservation values that many Native Americans appear to have held at the time of European contact. If so, then 1492 was a clash of Janusian timing: European nations reveling in the discovery of God-given riches just as Native American cultures were formulating a spiritual understanding of natural limits.

We know which of those two worldviews prevailed in the centuries that followed—a history that astounds us with the extinction or near-extinction of even the most superabundant creatures, from the great auk to the buffalo to the Atlantic cod, though these iconic species are best thought of only as reminders of a wholesale assault on animate life that left no species unscarred. In the midst of it all, a countercurrent emerged. A small minority of people still mark the beginnings of that turning with the 1864 book *Man and Nature*, by George Perkins Marsh, a pioneer of ecological thought. With the exhausting thoroughness of autodidactic science-geekery, he presented an inventory of "the extent of the changes produced by human action in the physical conditions of the globe we inhabit." For the most part, however, Marsh is a footnote, massively overshadowed by his more lyrical, less empirical contemporaries. I don't even need to use their first names: nature writing in the tradition of Emerson and Thoreau, of Wordsworth and Coleridge, has called on us to see the face of God in every trembling leaf ever since. To do otherwise is to fall into the cold rationalism so often said to have betrayed the wild world.

This modern love of the Earth is ironic—it is a reaction against the destruction of nature but is also a product of that destruction. Witness Great Britain, once home to deep forests, bears, wolves, wild boars, wild oxen. We celebrate England's Romantic poets for seeing divinity in a landscape that othe

found dark and threatening. Yet the Romantics were only opening their eyes to a new reality: almost every threat posed by that wild landscape had been vanquished. By the time of the Romantics, Britain was much as it is today—a deforested island, its fauna largely reduced to butterflies, birds, and hedgehogs.

The pattern repeated itself on the American shore. Thoreau wrote from a forest that had lost its capacity to instill fear in a young man's heart. (Marsh could have detailed this history for him; Marsh's childhood home near Woodstock, Vermont, had in his lifetime lost its moose, wolves, and mountain lions, and seen its spruce and hemlock forests replaced with European trees.) Annie Dillard's pilgrimage to Tinker Creek plays out in a denuded Virginia, and even Edward Abbey, that singular voice of wildest America, went to his deathbed never having seen a free-living grizzly bear. Such versions of nature still inspire wonder—I held a wild hedgehog in my hands last year and was speechless with the thrill of it. In fact, one might argue that the works that have brought us closest to nature have *depended* on a more welcoming wilderness. But another truth should be foremost in mind: that what we call nature today is a kinder, gentler, more depauperate world than at any time since at least the late Paleozoic, some 300 million years ago. Nature is not a temple but a ruin. A beautiful ruin, but a ruin all the same.

According to recent statistics, most people on Earth now live in cities, with few if any daily reminders of things ecological. There is considerable evidence that this disconnect costs us at a personal level. Among the most durable findings in the field of environmental psychology, for example, is that we prefer natural settings over the built environment. Among natural landscapes, we show the greatest preference for open spaces dotted with trees, with a little water nearby. (Picture the views from the apartments that border Central Park in Manhattan; as the biologist E. O. Wilson puts it, "To see most clearly the manifestations of human instinct, it is useful to start with the rich.") These preferences have a consistency across cultures and generations that approaches evolutionary natural law.

I want to call attention to two aspects of these discoveries. The first is that the salient feature of our most preferred environments—savanna-like spaces—is long sightlines, which would have helped us survive the eons when our species was still a link in the wild food chain. In other words, we prefer nature when it is unthreatening, and on that count, we have had our wish. The second point is that we nonetheless have a deeply embedded psychological attachment to the living world. Having lost our daily communion with that world, our modern spiritualization of it can be seen as a kind of prosthetic—or, if you prefer, a way of turning up the volume on a signal that is increasingly faint. We have created an imaginary connection with nature because we lack a tangible one, and we carry that connection in spirit because we no longer follow it in body. The sense of the divine that many feel in wild places is less a bond with nature than another symptom of the absence of that bond.

Ecologically speaking, this sanctified nature is not nearly enough. "We live more and more in an enchanted illusion of what nature is, which I think is counterproductive to conservation," says the Cornell University biologist Harry Greene. It's the back half of that statement—*counterproductive to conservation*—that contains surprises. At the time, Greene was responding to the movement that seeks, in effect, to protect feral mustang horses in the American West from natural life and death, permitting neither human culling nor wild predation nor starvation from drought or harsh winters, and instead using pharmaceutical contraceptives to control the population. This approach falls close to the farthest end of the spectrum of enchantment, where we find "end of suffering" activists who see a high moral calling in technocratic intervention against every cruelty that regulates natural systems: no more frogs swallowed alive by snakes, no more calf elk gored by grizzlies in front of their mothers' eyes, no more exhausted hummingbirds drowned during their arduous migration across the Gulf of Mexico. "Let's aim to be compassionate gods," concludes one essay from the end-of-suffering sect,

“and replace the cruelty of Darwinian life with something better.”

But such extreme examples aren't necessary. We might instead simply reflect upon the ecological consequences of our having created a wild world that has, for the most part, liberated us from fang and claw and distanced us from unseemly reality. Writing in the 2010 book *Trophic Cascades*, editors John Terborgh and James Estes, both prominent ecologists, describe the simplification of nature's architecture by human actions as a crisis “every bit as serious, universal, and urgent as climate change.” When fishermen's nets fill not with fish but jellyfish; when pestilent tsetse flies spread with the scrublands once held in check by browsing elephants; when overpopulating deer eat the flower gardens of suburban America—all of these bear the markings of the ecological cascade. Of greatest concern is that most of what has changed, and how, and at what cost, has not even been calculated. Here's one example that hints at the scale of the losses: the best available estimate suggests that whales before whaling ate up nearly 65 percent of the energy—as transformed into living things—produced yearly in the world's oceans. Paradoxically, however, the same seas that teemed with ravenous whales also brimmed with other creatures great and small, from swordfish to shad to oyster. “We know very little about the direct and indirect effects of reducing whale populations by more than 90 percent, but they must be substantial,” note Terborgh and Estes, with the typical restraint of lifelong scientists. It's knowledge that could be of some use to us right now. By conservative estimates, a single animal—us—now consumes at least a quarter of the annual productivity of the planet, with the critical difference that our myriad hungers are satisfied only at enormous expense to the abundance and variety of species.

Are we to blame a global society's accumulating insults against the biosphere on people who meditate in the desert or find divinity beneath the redwoods? No. But the way you see the world determines much about the world you are willing to live in, and the spiritual lens has failed us as a tool for seeing clearly. Here are Terborgh and Estes again: “There is little public awareness of impending biotic impoverishment because the drivers of collapse are the *absence* of essentially invisible processes . . . and because the ensuing transformations are slow and often subtle, involving gradual compositional changes that are beyond the powers of observation of most lay observers.” Our collective response to these shifts in our surroundings, as Michael Soulé, a founding figure in conservation biology, puts it, is to “excuse, permit, and adapt.” The romanticization of a denatured living world is one such adaptation. We have turned a fierce and ambiguous nature into a place of comfort, and if we embrace the result as a sanctuary of the soul, to be visited every second or third long weekend, then we may ultimately see little purpose in returning to a deeper and more risky engagement. We'll end up with the twin faces of Janus both looking the same direction, having found all the wildness we need in the tamed.

Every year, I try to return to that cabin where the bears roam and the salmon spawn and die, and the baby bats risk their new lives in fragile flight. There is no road; the access is by train, or by boat across a river of terrifying cold and current. I once told people that I went there for the peace and quiet, to escape into the sublime, and that was not entirely a lie. But I have to admit that I often feel a growing dread as the moment of entry into that wilderness approaches. It's not the solace of mountain and forest that keeps drawing me back. It is something more demanding.

Every day in that wild place is an opportunity to pass time with eagles, ravens, toads, snakes, moose, grouse, salmon, and the year's local black bear, which somehow always seems to be everywhere at all times. I often find myself filled with wonder, but the challenge of living nearer to nature will never be having to cope with more beauty, or that our hearts may explode from so much swelling. Instead, the challenge comes from the wilderness's countless mortal shocks, from maggots teeming in the brainpan of a dead deer, to the steady watchfulness required of life among large predators, to weirdly disturbing realizations such as that adult mayflies have no mouths, no digestive

tracts, no anuses. Yet another memory from this past year's visit leaps to mind: a strange preponderance of bleeding-tooth fungus, *Hydnellum peckii*, which weeps transparent beads of red liquid across the white pulp of its mushroom cap. If the bleeding-tooth fungus is the answer to any question, that question could only be "Why?"

If the modern spiritualization of nature is the product of distance and diminishment, observations such as these are the opposite, the outcome of muddy hands and scratched skin, of having time to waste in places where our species is a curiosity and a potential source of protein. Slowly, haltingly, I am coming to see the community of species around my cabin with the same eyes with which I have come to see other communities—to the extent that even that word, "community," sounds clinical and precious to my ears. Think instead of your friendships, or your neighborhood, those fragile constructions of toleration and embrace, of the heartwarming and the bleak. We understand our friends and neighbors as imperfect, even essentially tragic, and yet, at our best, we know that they are a part of us—that we are enriched when they are enriched, impoverished when they are impoverished. I am still new to the neighborhood of salmon, cedar, and raven, and I won't claim any insight into their world that is more profound than this: I feel their absence when I leave, and it's their presence that always draws me back again.

It hasn't been my experience that full-force nature directs the mind toward thoughts of positive vibrations or divine master plans. Nature itself is enough, its stories written in blood and shit and electrons and birdsong, and in this we may ultimately find all the sacredness we seem to need.

One final story: Several years ago, I interviewed a woman named Sally Mueller, who had moved with her family from New Mexico to the remote Tatlayoko Valley of British Columbia. She had, in effect, made the decision that I have never found myself quite ready to make—to seek a life in the wilderness. There, many happy years later, she was charged by a sow grizzly protecting her cubs. The animal stopped only inches away and, roaring, swiped with a paw, slicing through two layers of clothing and the flesh of Mueller's thumb. Only then did the mother bear's fury drain away. The grizzly retreated; the scales of life and death tilted back into balance; the crawl of time returned to its regularly scheduled programming.

"It was really a highly spiritual experience for me," Mueller said. She shared that revelation cautiously, aware that it would be difficult to understand. But in those terrible instants, she said, she knew that the bear was only doing what it must, and so was she, and so, too, were even the meadow grasses and the trees, the earth and the sky, and all of it was blurred into a pattern too infinite and ancient to explain. At last, Mueller found the words for the feeling: "It was just like coming home."

The Last Distinction?

FROM *Harper's Magazine*

HUMAN BEINGS HAVE long sought a definite marker between themselves and “the animals.” In the 1960s, toolmaking was considered such a uniquely human behavior that when Jane Goodall witnessed chimpanzees modifying twigs to root for termites, the naturalist Louis Leakey responded, “Now we must redefine *tool*, redefine *Man*, or accept chimpanzees as human.” Since then, other animals—crows, most recently—have been seen making and using tools. Ethological observation has similarly eroded other distinctions humans have claimed for themselves. But there remains a tradition—in literature and philosophy as much as in science—of treating language as the Rubicon that only humanity has crossed. In *Paradise Lost*, when Satan, disguised as the serpent, begins talking to Eve, she says in astonishment, “What may this mean? Language of man pronounced/By tongue of brute, and human sense expressed?” Animals do not talk. The idea is unnatural, satanic.

Speculation on the origin of human language was long discouraged among linguists; inquiry into the subject was formally banned by the Société de Linguistique de Paris in 1866, and the taboo there established persisted for nearly a century. The moratorium, a famous incident in the history of linguistics, began in the earliest days of Darwin’s influence, after the publication of *On the Origin of Species* but a few years before the publication of *The Descent of Man*, in which Darwin first explicitly discussed human evolution—including the evolution of language.

Of modern history’s important thinkers, Darwin may be the most chronically oversimplified. Distortions of his thinking began not long after his death. He treated humanity as a part of nature rather than over and above it, upsetting Europe’s philosophical tradition of the Great Chain of Being: the hierarchical ordering of all creation, rising in increments toward man’s perfection. This model of life was so firmly accepted that it survived even among those who accepted Darwin’s work, leading to a widespread misunderstanding illustrated by a graphic so elegant (and so reductive) that it’s become a pop-semiotic stand-in for the theory of evolution: the left-to-right single-file march of an ape morphing into a man, with its implication that evolution is a teleological progression and *Homo sapiens sapiens* the goal. The illustration does less to explain evolution than to reinforce the inaccurate (and specifically Western) idea of a radical break between humans and other animals.

Descartes, who wrote extensively on the philosophical problem of animal consciousness, argued that all nonhuman animals are instinctual automata, whereas humans alone think—*cogitant ergo sunt*—and therefore possess souls. The impulse to draw a circle around humanity underlies the question “What makes us human?” The way we phrase the question—which presupposes that the answer must be a definite *thing* we possess—tends to make language the most satisfactory answer.

Hence our fascination with feral children—the Wild Boy of Aveyron, Kaspar Hauser, Genie, and so on—cases of human beings isolated and deprived of language during the crucial early-acquisition period. What would it be like to have a consciousness but be unable to think in articulate language? For most people, to imagine the experience of inhabiting such a consciousness is close to impossible. The animal scientist Temple Grandin has written much on this subject, asserting that her autism lends her a unique insight into the way animals—cows, in her line of work—experience the world: wordlessly. “I think in pictures,” she writes in the opening pages of her memoir.

Words are like a second language to me. I translate both spoken and written words into full-color

movies, complete with sound, which run like a VCR tape in my head. When somebody speaks to me, his words are instantly translated into pictures. Language-based thinkers often find this phenomenon difficult to understand, but in my job as an equipment designer for the livestock industry, visual thinking is a tremendous advantage.

It would be absurd to suggest that because Grandin does not think primarily in language she isn't conscious, but the importance of language as a distinct marker between the human and "the animal" mind is still lodged in the Western models of consciousness.

In the thirties, the psychologists Winthrop Kellogg and Luella Kellogg briefly raised a chimpanzee named Gua alongside their own infant son, Donald. They aborted the project after nine months because Donald seemed to be picking up more behaviors from the chimp than vice versa. In a longer and more involved experiment that began in 1947, another psychologist couple, Keith and Cathy Hayes, attempted to raise a newborn female chimp named Viki as a human child. After seven years of home rearing and intensive vocal training (including speech-therapy techniques such as physical manipulation of the mouth), Viki could articulate, in a breathy and almost inaudible voice, four words: "mama," "papa," "cup," and "up."

These early experiments focused on language production over comprehension. But ape anatomy does not readily allow articulations of the kind necessary to speak. The human vocal apparatus consists of the larynx, the throat, the nasal cavity, the tongue, and the lips—all of which are shaped differently in nonhuman apes. Chimps' vocal tracts are shorter and straighter than ours, with higher larynges. When humans speak, moreover, we accomplish what's called a velopharyngeal closure by briefly blocking off air to the nasal cavity with the soft palate, allowing us to articulate hard consonants. Apes do not have this capability.

Even as far back as the 1920s, scientists wondered about the possibilities of gestural communication. "I am inclined to conclude from the various evidences," wrote Robert Yerkes, an early American pioneer of primatology, "that the great apes have plenty to talk about, but no gift for the use of sounds to represent individual . . . feelings or ideas. Perhaps they can be taught to use their fingers, somewhat as does the deaf and dumb person, and thus helped to acquire a simple, nonvocal 'sign language.'" Recognizing that nonhuman apes, though physiologically unable to produce the same range of sounds as humans, often communicate gesturally, another psychologist couple, Allen and Beatrix Gardner, of the University of Nevada, Reno, began experimenting with sign language in 1966, using as their subject a female chimp named Washoe. The focus on sign language, which resolved the main problems of the Hayes experiment, was also influenced by Jane Goodall's and Adriaan Kortlandt's ethological reports that chimps in the wild have systems of gestural communication that are highly complex and cultural, varying from one social group to another.

The Gardners housed Washoe in a trailer in their backyard and enlisted a small staff of graduate students to help teach her American Sign Language. Allen Gardner, a strict experimentalist, began the study with Skinnerian conditioning techniques, which are undeniably useful in any animal training. For example, they would wait for Washoe's "hand-babbling" to form something that looked like an ASL sign, then reward her with food or such displays of approval as clapping, smiling, and tickling. They would refine the sign with further rewarding and try to condition her to use it in correct context. They abandoned these methods not long into the experiment because Washoe had learned only one sign: "funny." Roger Fouts, who worked closely with Washoe her entire life, writes in his memoir, *Next of Kin*, that after the first year of the experiment Washoe picked up signs almost entirely from watching humans use them.

The methodological trickiness of the Gardners' experiment plagued it and other sign-language

experiments to come. ASL is a fully developed language, with movements and facial expressions that work together to create meaning; what Washoe learned was not ASL per se, but a collection of modified ASL signs that were fluid and subjective. Their interpretability became a major problem. At the outset of the experiment, the Gardners kept records of every sign—or near-sign—Washoe made, marking the time she made it, and in what context. As Washoe’s vocabulary grew and she began signing more frequently, data collection became difficult; soon the experimenters would record only her use of new signs. In order for a sign to be added to her theoretical vocabulary, three independent observers had to document that she made a “spontaneous, well-formed, and appropriate use of the sign.” That sign then went on the official list of Washoe’s working vocabulary only when she had used it spontaneously, articulately, and appropriately every day for fifteen days. By this measure, in 1970, four years into the experiment, Washoe had an active vocabulary of 132 signs. Although the Gardners tried to be strict with their data collection, skeptical linguists accused the experimenters of interpreting their data too generously. “Spontaneous,” “well-formed,” and “appropriately used” are in the eyes of the beholder—even three independent ones.

How does one determine whether an ape has made an ASL sign? Neither the Gardners nor the graduate students who worked with them were fluent in the language. “Each week I attended ASL classes at the Gardners’ house,” writes Roger Fouts, “but most of my learning came on the job with Washoe and her other student companions.” Being nonfluent, the experimenters were probably poorly equipped to teach ASL to a chimp—or anyone, for that matter. They were learning signs at the same time Washoe was, which meant they were also probably poorly equipped to interpret them. “Often the project directors themselves were uncertain about how a particular sign should be made,” writes Arden Neisser about Washoe in her book on sign language and the deaf community, *The Other Side of Silence*. “By the time it was taught to the chimp, ‘It lost something in translation,’ said a deaf friend ruefully.”

The Gardners’ experiment was a direct precursor to the Columbia University psychologist Herbert Terrace’s whimsically named Nim Chimpsky project, which was beset by many of the same problems as well as new ones, mostly of Terrace’s making. The most ambitious and publicly visible of several sign-language experiments with apes throughout the 1960s and ’70s, Terrace’s Project Nim is the subject of a 2011 documentary of the same name, directed by the Academy Award-winning filmmaker James Marsh. Following upon Elizabeth Hess’s 2008 book, *Nim Chimpsky: The Chimp Who Would Be Human*, the film chronicles the chaotic life of Terrace’s subject.

Noam Chomsky, the punny namesake of both the project and the chimp, is never mentioned in the film, which focuses on the human elements of Nim’s story rather than the scientific controversies surrounding it. This is an odd absence, since Chomsky more than any other thinker upheld Descartes’ torch of human exceptionalism in the twentieth century. Chomsky’s theories of transformational grammar, universal grammar, and the innateness and human uniqueness of language defined the debate over language for decades. These theories rest on the “poverty of the stimulus” argument: language is so complex, and infants learn it in such relatively little time, that it can’t possibly be learned entirely through external stimulus; there must be an innate language-acquisition “device” or “organ” in the human brain. We were told to look for it somewhere in the left hemisphere.

Prior to recent scientific advances, neural anatomy was a dark frontier, and there was no clear evidence for or against the language-acquisition device. All we had was Chomsky’s promise that it must exist and that it must govern our understanding of grammar and syntax. Rather than argue with Chomsky’s anthropocentric definitions, some researchers aimed to prove that an animal could communicate in ways that filled out Chomsky’s checklist of what makes language—principally, that an animal could come to understand and use grammar. Proving that an animal could be “taught” to

communicate using language—as narrowly conceived by Chomsky—became a holy grail for language researchers. Herbert Terrace sought this prize by way of Nim Chimpsky.

There is something glib and thoughtless about bestowing on another conscious being a pun for a name. Glibness and thoughtlessness, as one sees in the documentary, are just a couple of Terrace's winning traits, and Nim Chimpsky's name was only the first indignity in a life full of indignity and suffering, which is the main subject of Marsh's film.

Terrace, who still conducts research at Columbia, planned to raise a chimpanzee in a human home, with no contact with other chimps, and immerse him in sign language from infancy. Just days after his birth in Norman, Oklahoma, in 1973, Nim was taken from his mother—who had previously had six infants taken from her for experiments. Terrace turned him over to Stephanie LaFarge, a former student (and a former lover) of Terrace's, who had generously and perhaps recklessly volunteered her own New York home and large family to take in baby Nim as a foster child. The LaFarges were supposed to begin speaking to Nim in ASL within months, though not a single member of the household knew the language. Stephanie's husband, W.E.R., was a poet with a ponytail and a patrician pedigree; they lived with a swarm of children from previous marriages in a brownstone on Manhattan's Upper West Side; and everyone in the picture seems to have been smoking a lot of pot. Now add to this environment one infant chimpanzee. As Stephanie's daughter, Jenny Lee, says in the film, "It was the seventies."

Herb Terrace comes across so negatively that one wonders how much thought he gave before consenting to filmed interviews. Disliked by every other interview subject, Terrace appears irresponsible, smug, careless, cowardly, disloyal, vain, and given to having sex with his students. During the experiment, Terrace had an affair with Laura-Ann Petitto, who was an eighteen-year-old undergraduate when she began working on the project and who became one of the most involved of Nim's early caregivers. Petitto worked with Nim while he was still living with the LaFarges (Stephanie LaFarge calls her, with jealousy and a sniff of classism, "a cute little thing from Ramapo") persisting in her work as the chimp ripped apart the LaFarges' curtains, books, and marriage, and moving with him when Terrace secured for the experiment a sprawling Georgian estate in the North Bronx that was owned by Columbia and had been sitting empty for years.

Terrace's affair with Petitto is noteworthy mostly because it interfered with the project. In Petitto's words, Terrace "abruptly" ended their romantic involvement—a diplomatic phrasing that sounds like the shutting of a cellar door. Whatever happened, she left the experiment, upsetting the balance of Nim's emotional life yet again. "It's the humans I wanted to leave," says Petitto, "not the chimp."

Terrace's participation in the experiment was by all accounts fairly minimal. He showed up for photo ops, and his name was of course listed first on the resulting paper, but he left the bulk of the work to his students. Bill Tynan, another of Nim's early caregivers, describes Terrace as "an absentee landlord" who only occasionally put in an appearance at the mansion where Nim was imprisoned in luxury like a mad aristocrat out of some gothic novel.

After four years, Terrace abandoned the experiment, largely because Nim's increasingly violent and unpredictable behavior—he was, after all, a growing chimpanzee—had created insupportable liabilities. "I was probably worried that she would sue me," Terrace says—with characteristic bluntness and lack of self-awareness—of an incident in which Nim grievously injured Renee Falitz, a sign-language interpreter who was the only person fluent in ASL ever to work on the project. So Terrace called an all-hands-on-deck meeting at which he shocked and angered his staff by announcing that the experiment was now over. Terrace had Nim tranquilized and flown back to his birthplace. Nim went to sleep in his palace and woke up in a hellish place now infamous among captive-ape researchers for its inhumaneness.

"It turned out to be a surprisingly more primitive facility than I remembered," Terrace says of the

compound run by the University of Oklahoma psychologist and animal breeder William Lemmon, which served as a sort of chimpanzee-research hub in the 1960s and '70s. Electric fencing, metal cages, guns, and cattle prods were Lemmon's tools of subjugation; this was a place where chimps were treated like animals—or, rather, prisoners—not like spoiled human children. (In his memoir, Fouts claims that Lemmon wore a ruby ring that he had trained his chimps to kiss. But that's another story.) Nim entered this environment having never met a chimpanzee other than, however briefly, his mother. In the most affecting moment of Marsh's film, Terrace visits Oklahoma a year after leaving Nim there. Nim recognizes Terrace and erupts with jubilant relief, shrieking and rushing to hug him. Bob Ingersoll, who worked at Lemmon's facility, infers Nim's thoughts on seeing Terrace again: "Holy shit! I'm going back to New York!" Terrace left that day, and Nim never saw him again. After Terrace's departure, Nim lay still in his cage, refusing food.

Raspy and long-haired—he wouldn't look out of place in a Santa Cruz head shop—Bob Ingersoll was the last and most enduring force for good in Nim's life at a time when everyone else, including Terrace, seems to have given up on him. Ingersoll rallied to get Nim out of the medical research facility to which an insolvent Lemmon had sold him and many other chimps, and again came to Nim's aid after he wound up sequestered at the Black Beauty Ranch, a rescue home for horses in Texas run by an activist with good intentions and no clue about how to care for a chimp. There is footage of Nim alone in a concrete room, maniacally shoving a metal barrel around on the floor. These images are capable of testing the empathy of even the most rigid human exceptionalists. Don't call it anthropomorphism; the emotions this animal displays are unmistakable: sadness, bitterness, loneliness, betrayal, rage.

Marsh's documentary avoids the depths that lie beneath Terrace's bizarre, tragic experiment—things that could be said about linguistics, the imperfect nature of science, and some of the most interesting areas of philosophy. (Making a film about animal language without mentioning Noam Chomsky is a bit like writing a book on the French Revolution that neglects to bring up Louis XVI.) One of the narratives that remains largely untold is the devastating effect the experiment had on the future of research in the field.

Terrace made himself one of the most powerful enemies of such research when he declared, in a 1979 paper in *Science* entitled "Can an Ape Create a Sentence?" and in a related book, that Project Nim and by extension *all* animal-language experiments were bunkum—the wishful thinking of sloppy scientists deceived by their subjects' clever and complex ways of begging for treats. Ape-language research has yet to recover from Terrace's public surrender to Chomsky—a turnaround that felt especially treacherous considering the inexactitude of Terrace's own science.

Many of the problems of Project Nim arose from Terrace's faithful acceptance of Chomsky's syntax-based definition of language, and from a resulting methodology rooted in the familiar techniques of second-language instruction. The word itself, "instruction," is indicative of a wrong-headed way of thinking about the acquisition of a first language. Human infants do not really need to be "instructed" in their first language to pick it up—this was at the heart of Chomsky's argument in the first place. When Terrace decided that the environment surrounding Nim was too chaotic, he resolved to have Nim instructed in a "classroom" at Columbia. The classroom was small, windowless, and whitewashed, with nothing in it except Nim, the person working with him, and some drab, minimal furnishings. The idea was to hone Nim's concentration by isolation. We see his caretakers struggling to maintain his restless attention. Joyce Butler, one of his keepers, tells of her realization that Nim was making the "dirty" sign—indicating that he had to use the bathroom—simply in order to get out of there. Such an environment makes little sense for what Terrace and his staff were trying to do: help a conscious being acquire a first language. Decontextualizing language from the everyday in

order to foster its acquisition is like putting a seed in a sealed jar to help it sprout.

The case of Kanzi is a helpful counterexample. Beginning in the mid-1970s, Duane Rumbaugh and Sue Savage-Rumbaugh, who had also worked with Bill Lemmon at the University of Oklahoma, began a series of language experiments with chimpanzees and, later, bonobos—a cousin species about which relatively little was known at the outset of their research—employing a table of invented lexigrams: arbitrary, nonrepresentative pictures signifying certain things (actions, foods, places, the names of apes and people involved in the experiment, and so on). One reason for their creation of the lexigram system was to help alleviate the data-gathering problems of the sign-language experiments. Whereas both the Washoe and Nim experimenters struggled with ASL and its interpretation, Rumbaugh and Savage-Rumbaugh had only to decide whether an ape was touching a picture that was neatly blocked off from others in a little square, which is a much more objectively measurable datum. In the early 1980s, the couple were trying to get Matata, an adult female bonobo, to understand and use the lexigrams. Matata had recently stolen an infant named Kanzi from a bonobo in captivity. Kanzi was either close by or clinging to his adoptive mother while the research was going on. They never had much luck getting Matata to understand the lexigrams, but later realized that her son had picked up many of their meanings—spontaneously, and with no deliberate instruction. That is, in the same way one acquires a first language.

Since then, the experiment has expanded along with the group of bonobos involved in it. It is the only ape-language experiment still active, and is currently based at the Great Ape Trust's research facility in Des Moines. Many of the bonobos understand not only the lexigrams but also a great deal of spoken English. One can view online videos of Kanzi carrying out simple tasks at spoken request. The experimenter—wearing a welding mask to help prevent unintentional facial cueing—might say, for instance, “Put the snake on the ball,” and Kanzi responds by placing a toy snake on top of a plastic beach ball, suggesting comprehension of verb, word order, and preposition. The room is strewn with these various artifacts—balls, soap, stuffed animals, water pails, plants—resembling far less Nim's stark isolation chamber than, say, a nursery: a space including not only words, but things to talk about.

Researchers who conduct language experiments with animals—especially complex, social, intelligent ones like great apes—sometimes draw the public's interest, but after Project Nim they have had a hard time persuading the scientific community to consider their work anything more than wishful thinking. Few have done more to aggravate animal language's respectability problem than Herb Terrace himself. For ape language's skeptics, he provided the voice of the disgruntled inside man. In 1980, shortly after Terrace published his paper denouncing the project in *Science*, the Indiana University linguist Thomas Sebeok organized a conference on the “Clever Hans phenomenon.” The term refers to humans anthropomorphizing animal behavior in such a way as to assume cognitive or communicative processes that aren't really occurring. (Clever Hans was a horse who, his trainer believed, could answer simple mathematical equations, among other things, by stamping out solutions with his hoof; by isolating the horse from his owner, researchers found that Clever Hans was determining his “answers” by picking up subtle subconscious cues from his human—still impressive, to be sure, but the horse was not doing arithmetic.) Sebeok invited Herbert Terrace to the Clever Hans conference, during which he stridently pronounced that “the alleged language experiments with apes divide into three groups: one, outright fraud; two, self-deception; three, those conducted by Terrace.”

“The combined effect of Sebeok's Clever Hans Conference and Terrace's *Science* paper,” Sue Savage-Rumbaugh later wrote,

was . . . to instigate an extremely rapid and violent swing of the pendulum. Ape-language research went from being a field of perceived intellectual excitement and public acclaim to one

that, at best, should be viewed askance. Suddenly, it became extremely difficult to have research papers reviewed, let alone published. And funding for most of the major projects virtually dried up.

The end of Project Nim marked the end of an incautious but intensely curious open-mindedness in the culture of science that was probably reflective of a change in culture at large: free-spiritedness was out, and the skeptical, cynical eighties were in. Jenny Lee's remark ("It was the seventies") not only calls attention to the look of the film—all the grainy and garishly colorful footage of chimp caretakers, knee socks, bell-bottoms, and sideburns—but also suggests that this story could not have happened in the way it did at any other time. The backdrop of hedonistic abandon behind this story may strike a viewer today as humorous or appalling. One wonders how much serious scientific inquiry was going on in an environment in which everyone was in bed with everyone, and Nim was plied with booze and pot right from infancy. To watch a chimpanzee puffing on a joint is disquieting, in equal measures funny and disturbing. We enjoy mocking that sliver of biological difference between us and chimpanzees. Yet anyone who has ever looked with curiosity and respect into the face of a chimpanzee has seen a presence there. If we abandon the notion that language is necessarily the bedfellow of consciousness, we get a better understanding of ourselves, while our relationship to the other beings we share this planet with becomes more enlightened, more humble, and more humane.

Talk to Me

FROM *Outside*

STRETCHING NORTH AND east from Grand Bahama Island, the Little Bahama Bank is a vast, crescent-shaped undersea plateau of sugar-white sand, patchy seagrass, and isolated coral reefs, layered under a shallow veneer of translucent water. It sits just 60 miles east of West Palm Beach, across the Gulf Stream. Yet despite its proximity to the condo sprawl of Florida, it is another world, a wild seascape of endlessly changing water and light, fast-moving thunderstorms, and teeming bird and sea life.

My first contact with its alien underwater culture involved a snorkel, a mask, and fins. I dropped into the 83-degree sea, and on the periphery of my vision six sleek shapes wheeled and turned, gliding with perfect ease. Three were larger and mottled with spots. The others were colored a smooth, gunmetal gray. One broke formation and arrowed my way, scanning me with a sophisticated sensor system. I heard a high-pitched buzz that sounded like a zipper being ripped open and could feel a light vibration in my chest. As the creature shot past, it rolled slightly to make direct and steady eye contact.

The scientific name for the species is *Stenella frontalis*. The more common name is the Atlantic spotted dolphin. There is a group of about a hundred of them living near the western edge of the Little Bahama Bank, and for the past twenty-eight years Denise Herzing, a marine-mammal biologist in her midfifties, has devoted her life to learning about them and their culture. Since 1985, she has spent close to one hundred days every summer here, enduring baking sun and nosy sharks so she can observe their wild society. At this point, she recognizes about sixty of the dolphins by sight. (The others she identifies using her photo catalog.)

Over the years, Herzing has had close to 2,500 encounters with these dolphins and spent some 1,500 hours in the water with them, accumulating research for the Wild Dolphin Project, a nonprofit in Jupiter, Florida, that she founded in 1985. She has an extensive video and sound library of the clicks and whistles the dolphins use to communicate. She has also learned intimate details about their complex world—how males form tight coalitions and cruise the waters like scrappy gangs; how young females babysit calves to prepare for motherhood; how everyone seems to have sex (or at least play a sex) with everyone. “It’s really interesting to see what’s going on in the mind of another species,” says Herzing, who is an affiliate assistant professor in the biological sciences department at Florida Atlantic University and has written or collaborated on some thirty scientific papers about the dolphins. “They have the potential to show you their world in real time.”

Now Herzing plans to take her relationship with the spotted dolphins to an ambitious new level. She is refining a set of portable underwater communication devices that can recognize and generate dolphinlike whistles, and she plans to use them to establish two-way communication. She’ll start by exposing the dolphins to a few of the whistles, using pattern-recognition software to tell her, via earphones she’ll wear underwater, if they use them to whistle back. Herzing hopes that once the dolphins, who are skilled mimics, get the idea, they can build a communication system together. “Maybe it will lead to an extensive artificial language,” Herzing says. “But the real breakthrough would be if the dolphins introduce their own vocalizations and whistles.”

It’s a radical goal. Herzing the scientist is trying to achieve something that has never been done before: two-way communication with a wild species. Herzing the person has a more existential aim: to open up an entirely different view of the planet and its creatures that is not so monumentally human-

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