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How humans made H5N1

THE QUEST TO BOTTLE PLACE
Distilling the scent of the desert

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Healing on the edge



Howl

THE DARK SIDE OF WOLF REINTRODUCTION p.22



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Into the Wilds

BY KATHERINE HARMON COURAGE

IN THE SUMMER OF 1989, two reporters, brothers Kevin and Todd Berger, drove Kevin's pale yellow Toyota pickup truck out from the Bay Area to rural northern Montana. They'd caught scent of a brewing controversy out there and went to track down a reclusive wolf biologist.

The biologist was Diane Boyd, and her intimate study of wolves made her a central character in the early debates about reintroducing gray wolves to the United States' Northern Rockies. The brothers Berger set up their tent near where she lived—in a small cabin, without running water or electricity, in a remote meadow. Eventually a mutual connection convinced Boyd to sit for an interview. Boyd joined them in their tent, talking wolves into the chill of the summer night.

The resulting story, "Return of the Wolf" ran in 1990 in Berkeley's *The Monthly* and was one of the first deep journalistic looks into the charged politics of wolf reintroduction in America—an effort that wouldn't start in practice for five more years. The encounter with Boyd in the wilderness stuck with Kevin Berger, a founding editor of *Nautilus*. (The article was memorable in another way, too: Through it, he met his mate, Teresa, who was the story's editor.) So last year, when Kevin saw Boyd was publishing her first book, a memoir, he was back on the trail.

This time, he flew out, rented a Toyota RAV4, and drove far out of cell range down a long dirt and gravel road to Boyd's new cabin (she still doesn't have running water). He spent two days with her, hiking and talking, and the next six months talking here and there with dozens of other sources—ranchers, park rangers,

biologists, advocates, hunters, lawyers, geneticists. In this issue's "Howl," he masterfully waves together this sweeping work to take us into the bowels of America's fraught relationship with its wildness, the other creatures who share this landmass, and the ways in which even our best intentions can miss the wolf for the pack.

In wilderness, with all of its dangers, can also come healing—not just for wild animals, but also for the human animal. In the mountains of Slovenia, a group of recent widows from the war in Ukraine and their children recently spent five days hiking with therapists and mountaineering experts. By the end of the program, they were facing a cliff. And asked to rappel down it. For 300 feet.

Journalist Florence Williams joined these women. The author of books including *The Nature Fix*, Williams was curious to know if such intense outdoor adventure therapy could help those in the throes of such extraordinary trauma and stress. In wild times, one clinical therapist on the trip told Williams, these experiences can help crystallize "your own stability in an environment that is unstable."

In the pages ahead, we'll also bring you to the Sangre de Cristo Mountains in New Mexico to learn a landscape through its scents; inside the mind to understand how our own brains get in the way of understanding consciousness; 110,000 feet into the sky, where advanced balloons are lofting new telescopes for a better look at the heavens; and to the deep quiet author Pico Iyer has called upon to weather wildfires and grief.

Onward into the wilds.





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THE PORTHOLE

Short sharp looks at science

ANTHROPOLOGY

This Mummy's Tattoos Are Better Than Yours

T ALL STARTED with a Roman pot. A new laser imaging technique revealed Greek inscriptions on the pot that had been hidden, which surprised archaeologists. But when Judyta Bak, a Polish archaeologist from Krakow, read the study, she didn't care much about the pot. She wondered what would be revealed if she shone the laser on the 100 mummies she was studying in coastal Peru, some of which are more than a millennium old.

Bak got in touch with Michael Pittman, who developed the laser technique, known as laser-stimulated fluorescence, which excites molecules on or below the surface of an object and can reveal hidden soft tissues without destroying them. He had used the technique to study details of Roman wall paintings, glass mosaics, and dinosaur fossils. Bak invited Pittman to come out to Huacho, on the central coast of Peru, a region known for the greatest documented number of mummy tattoos on Earth.

Bak had already identified tattoo designs on the mummies' bodies, but these were blurred under standard white light due to ink bleed and decomposition. "We came up with a hypothesis that the skin should glow," under the laser light, but that the tattoos would not, Pittman says. "Perhaps with this contrast we could see more. That was the theory."

They found what they were looking for: Under the laser's beam, beautifully detailed geometric patterns



and animal shapes, mostly birds and monkeys, popped from the mummified skin. The real surprise lay in the precision of the lines the lasers revealed, their thread-like quality: Some lines were just 0.1 millimeters wide, the thickness of a standard piece of paper. The mummies belong to a pre-Columbian culture known as the Chancay, whose celebrated tapestries and pottery featured designs similar to those inscribed on the mummy skin. But the tattoos were far more intricate, suggesting great skill and a special emphasis on tattooing as an artform in Chancay culture.



ANCIENT INK Archaeologists used a new laser technique to uncover hidden detail in tattoos on thousand-year-old mummies from the central coast of Peru. The lasers revealed that some of the ink lines were just 0.1 millimeters wide, the thickness of a piece of paper, which requires great skill and suggest tattoos were central to Chancay culture.

Under the laser's beam, geometric patterns and animal shapes popped from the mummified skin.

"This level of intricacy in the tattoos [suggests] that they were a focus in the society's aesthetics," says Pittman. The tattoos may have been a marker of status, as only some of the mummies had them, but their meaning remains uncertain. Pittman and Bak published their findings in the *Proceedings of the National Academy of Sciences*.

"Tattooing is very widespread in South America both today and in pre-colonial contexts," says José Oliver, an expert in Latin American archaeology at University College London. It serves many functions: to showcase identity, ethnic affiliation, or social status, or as a ritual for the "protection of the person or body," he says. They can also serve to mark differences in age or gender.

All tattoos fade and flatten over time, which blurs the designs, but the laser imaging revealed the artwork as it would have appeared when freshly applied. "What we were able to do is image a bit deeper into the skin, where you can bypass the 'bleed' from tattoos," says Pittman. For comparison, the width of the lines revealed by the

lasers were three times as fine as what is usually applied today by a #12 needle, a staple in tattoo shops, colloquially referred to as the "standard" needle.

Painting on skin with this level of intricacy requires enormous effort. Because of the level of detail, the authors of the study believe that the artists used needle-based tattooing, rather than cutting and filling the skin with ink. They further speculate that tattoo artists likely relied on a cactus needle, or a sharpened animal bone for their artwork—although no evidence of the exact technique has been discovered yet. They believe charcoal was used for ink.

The Chancay thrived between 500 and 1,300 years ago, but their coastal state was likely absorbed by the Inca Empire. There are no known descendants today that identify as Chancay, and the mummies that Pittman studied are housed at the Archaeological Museum "Arturo Ruiz Estrada" in Huacho, Peru. They were buried alongside beautifully crafted dolls and other textile artifacts.

The oldest known tattoo belongs to Ötzi, a 5,300-year-old "Iceman," whose body was exquisitely preserved in glacier ice in the Alps. The significance of Ötzi's tattoos has been much speculated upon, including the possibility that they were applied medicinally. As a next step, Pittman wants to use lasers on Ötzi's tattoos.

"I'm hoping we can push the level of detail in tattoos back in time," says Pittman.

—Elena Kazamia



PSYCHOLOGY

Why Do Some People Look Like Their Dogs?

IN THE DISNEY ANIMATED FILM *101 Dalmatians*, there's an amusing sequence in which lookalike pairs of people and their dogs parade across the screen, the resemblances between human and canine in both shape and facial expression comically exaggerated. It's funny because it plays off the impression many people have that pets look like the owners who care for them.

But what's really behind this impression? Do we just think that dogs resemble their owners because we only tend to notice and remember such extraordinary instances, and ignore it when they don't look alike? This is called the "availability heuristic." We forget what's unremarkable.

Psychologist Yana Bender and her colleagues at Friedrich Schiller University in Germany decided to try to find out. They recently conducted a systematic review of studies probing for similarities in dog-human dyads and found that people actually resemble their dogs more often than chance would predict, not just in physical characteristics but also in personality and behavior. Their research, which analyzed 15 studies, was published in the journal *Personality and Individual Differences*.

It turns out that when you give people shuffled pictures of dogs and their owners, they are consistently good at guessing which human owns which dog. This finding held across four separate studies, the team of researchers found, even when the mouths of the dogs and owners were hidden—but not the eyes. In one

study, test subjects were only able to match purebred dogs to their owners, however. In a more objective measure, overweight dogs were found to be more likely to have owners with high body-mass index.

Two hypotheses could explain such resemblances. The first is that dog owners *choose* dogs that resemble them. This possibility is supported by a couple of studies that show that women with long hairstyles express greater preference for long-eared dog breeds, such as beagles and Springer Spaniels, while those with short hairstyles tend to prefer short-eared breeds, such as Siberian huskies or Basenjis. Dog owners in general might do this because of the general finding that people prefer others who resemble themselves, or because of the mere-exposure effect, which is that people prefer things that are familiar. Since people see themselves a lot, they like that equivalent look in dogs.

The second possibility is that dogs and humans become more similar in appearance over time. If this were happening, owners should resemble their dogs more when they've been with the dog longer. However, the research reviewed suggests people's abilities to match owners with their dogs in photographs is not affected by how long the owner has had the dog, casting doubt on this hypothesis. The only resemblance that seems to grow with time is weight—overweight owners are more likely to have overweight dogs the longer they have been together. This is possibly due to the dog living a similar lifestyle as the owner.



The similarities between dogs and their owners don't end with appearance. Bender and her colleagues found multiple studies that showed significant correlations between dogs and their owners on all five major personality dimensions: neuroticism, extraversion, openness, agreeableness, and conscientiousness. Extraverted owners tend to report that their dogs are extraverted and the dogs are also observed to display more sociable behavior. Dog owners who rated themselves as emotionally unstable had dogs who showed higher rates of aggression toward their owners and more stranger-directed fear.

Only one of eight studies the team reviewed found weak correlations between dog and human personality, but the researchers note that study looked only

People are consistently good at guessing which human owns which dog.

at owners who had adopted their dogs within the past two months. They propose that emotional mirroring between pets and owners may evolve over time, a psychological process that is well documented in humans. Dog owners also expressed higher levels of satisfaction when they felt their

dogs' personalities and behaviors resembled their own.

Humans have had a friendly relationship with dogs for some 30,000 years. Many of us see our dogs as members of our family. We are social creatures, sensitive to the goals and moods of those around us. Dogs also are sensitive to human moods. When we select dogs to own, we tend to seek dogs that "fit."

So if you think you look and act like your dog, you might be right.

—Jim Davies

ASTRONOMY

The Slingshot Effect of Gravity

SPACE TRAVEL BEGAN as a struggle against gravity, a bid to overcome this fundamental law of the universe. Scientists kept building bigger and faster rockets so they could overcome the pull of the Earth and voyage into the vast unknown. But it soon became apparent that gravity is one of cosmic exploration's greatest accomplices. For more than 50 years, this elemental force has been helping slingshot spacecraft around the solar system and extending the ambitions of space missions.

On January 8 this year, the BepiColombo probe executed its sixth and final "gravitational slingshot" around the planet Mercury, bringing the probe to within 100 miles of the surface. It was the lowest planetary fly-by ever, allowing the probe's cameras to photograph the mysterious planet in detail never before possible, revealing vast lava plains and craters in permanent shadow near its north pole where temperatures dip to -280 degrees Fahrenheit. The force of that slingshot

Gravity assists are sometimes likened to skipping a stone across the surface of a pond.

then propelled two orbiters on the probe toward their final stable orbits around the planet.

The BepiColombo probe is named after the late Italian mathematician and engineer Giuseppe "Bepi" Colombo, who first proposed using gravity as a slingshot for spacecraft in 1974. At the time, a robotic NASA probe named the Mariner 10 was set to explore both Venus and Mercury, the first time a space probe would explore two planets in one mission. Colombo calculated how a single slingshot around Venus could bend



MERCURY'S CLOSE-UP From left to right; Mercury's shadowy north pole revealed by M-CAM 1, Mercury's sunlit north viewed by M-CAM 1, Lava and debris brighten Mercury's surface.

the rocket's trajectory, enabling it to fly past Mercury multiple times while using hardly any rocket thruster fuel. The rocket ultimately made three such flybys, the nearest only 200 miles above the surface, providing our first up-close looks at Mercury.

The gravitational slingshot, also known as a gravity assist maneuver, allows a space probe to radically change its speed and direction. Navigators here on Earth can work out exactly where the probe needs to be and when to take advantage of a planet's gravitational pull. If a space probe approaches a planet from behind as the planet travels along its orbital path, for example, the planet's gravity will grab hold and accelerate it; but a probe approaching in the opposite direction will lose relative speed. Gravity obeys strict laws and the exact locations of the planets are well known, and so these distant navigators can calculate precisely when to fire the probe's rocket thrusters, in short bursts known as "burns," to guide it through the gravitational slingshot and ensure it is thrown off into space on the next leg of its long journey—a maneuver sometimes likened to skipping a stone across the surface of a pond.

Gravity assists performed at low altitudes above the planet—a few hundred miles, say—can impart much greater changes to a probe's trajectory than gravity assists at extreme distances, sometimes hundreds of thousands of miles away. And because the planets orbit the sun in a constant and predictable celestial dance,

space navigators can arrange a whole series of slingshots around different orbiting bodies to carefully orient a probe's trajectory.

Exploiting gravity like this is now a regular feature of space travel, and has been used by many space probe missions—including Pioneer 11, the Voyagers, and the New Horizons probe to Pluto—to preserve valuable rocket thruster fuel as they explore the solar system. In fact, only a few recent space missions have not relied on gravity assists—mostly ones that aim to measure aspects of the sun itself, which needed no such assistance, or ones that travel to the Lagrange point of gravitational stability between the sun and the Earth, a location about a million miles away that serves as a low-maintenance hangout for many robotic solar observatories.

When a space probe relies on a gravity slingshot rather than on rocket thrusters, it can carry far less fuel to achieve the same changes in trajectory; and carrying less fuel means a probe can be larger and schlepp more scientific instruments. The two orbiters on the BepiColombo probe, for example, have a combined weight of a little more than four tons, which makes it one of the heaviest probes ever sent to space.

Spacecraft engineer Ignacio Clerigo, the European Space Agency operations manager for the BepiColombo mission, says BepiColombo's path through space is one of the most complicated ever attempted and testifies to the importance of gravitational slingshots for making



it possible. Precise calculations for the trajectory had to be quickly redone last year, when the probe's thrusters failed to produce full power; but BepiColombo has successfully completed two slingshots around Mercury since then, he says.

Although its target is Mercury in the inner solar system, an average of just 35 million miles from the sun, BepiColombo's voyage has been at least as complicated as a space probe voyage to an outer planet, like Jupiter, almost 500 million miles away—and maybe more so. Mercury's accelerated orbit around the sun means critical events occur much more quickly: The probe's last two slingshots around Mercury, for example, occurred within just a few weeks of each other, while space probe slingshots around outer planets typically happen less than once a year, he says.

Physicist Roberto Peron, an expert in gravitation physics at Italy's National Institute of Astrophysics, explains that slingshots can significantly change both a spacecraft's direction and speed—something otherwise only possible with fuel-hungry thrusters. But relying on gravity slingshots takes a lot of time, he says: BepiColombo, for example, launched to Mercury more than six years ago and completed its first flyby of the planet three years later. The probe could have used a direct transfer orbit, with rocket thrusters, to cover the same distance in less than two months.

Nevertheless, Peron expects gravitational slingshots to continue to be widely used in the years to come. Once the greatest enemy of space travel, gravity has become a cherished friend.

—Tom Metcalfe

ZOOLOGY

How to Tell a Leopard from Its Roar

THE LEOPARD'S ROAR is a distinct sound. A repetitive pattern of hoarse and guttural calls, it is often compared to the rough music of a saw being pushed and pulled through a giant tree trunk. These "sawing" roars are also highly individualized, shaped by each leopard's physiology and environment, differing in measurable ways from one leopard to the next.

Now researchers have figured out how to tell leopards in Tanzania apart by analyzing the differing temporal patterns in their roars. The researchers were able to use their analyses of leopard roars to accurately identify a leopard 93 percent of the time, a method that could help conservationists track these big cats over much larger areas than they do now. Understanding the population sizes of endangered species is critical for conservationists and policymakers when it comes to managing landscapes.

Leopards are classified as vulnerable to extinction—and in some places in Africa they are now considered "locally" extinct—but they are difficult to study because they are nocturnal, solitary, elusive, and roam widely over home ranges of up to 300 square miles.





Approximately one third of Tanzania already comprises protected areas for the preservation of wildlife and ecosystems, but as human populations continue to grow, so does demand for land and resources. Habitat loss is among the greatest threats to leopards, which increases risk of human-wildlife conflict: Attacks on livestock, a target for the big cats, often drive these conflicts.

The project required sifting through 75,000 hours of acoustic data, but was something of a happy accident, says Jonathan Growcott, lead author and a Ph.D. student at the University of Exeter. “We got really lucky,” he says.

Growcott was working with another biologist named Matthew Wijers to track animals in Tanzania’s Nyerere National Park. They had placed acoustic monitors and camera traps together in the same locations so that they could capture not just video but also audio of creatures walking past. Growcott asked Wijers if he thought they would hear the footsteps of the leopards, given they are so stealthy in the wild.

To find out, they began listening to the audio paired with video of the leopards, and noticed that as leopards were walking past the cameras, they were also vocalizing. This meant they could sort through the audio data by noting time stamps on the camera traps when the leopards appeared. While audio data was captured continuously, the camera traps only recorded video when triggered by motion.

Growcott and his colleagues gathered data from 50 camera traps that were paired with audio recording units across 174 square miles of Tanzania’s Nyerere National Park. Over 62 days, researchers recorded 217 roars from seven members of one of Africa’s most elusive and solitary species. Once roars were isolated, audio analysis algorithms allowed Growcott to determine that the frequency contours of those roars could be used to identify individual leopards with incredible accuracy.

Studying animal vocalizations, a field known as bioacoustics, has long been used to monitor birds, primates, and marine species, but researchers have only recently begun to use it on big cats in Africa. Beyond the challenges of finding leopards in the first place, Growcott says that suitable technology is still emerging—earlier attempts to study vocalizations of lions, wild dogs, or spotted hyenas happened mostly with handheld microphones.

The frequency contours of those roars could be used to identify individual leopards with incredible accuracy.

“Those studies relied on going out and tracking the animals, spending an awful lot of time in the field, and having to know exactly which individual you’re recording. It takes a lot of resources. With the low density of these animals, acoustic studies just didn’t happen.” Putting monitoring collars on the cats, another alternative, is expensive, invasive, and risky for researchers.

Kirsten Young, a senior lecturer in ecology at the University of Exeter who was not involved in Growcott’s study, says there are limitations of acoustic monitoring for conservation purposes. “We need the animal to be making sounds, and we know that there are periods where they are silent,” she wrote in an email. “If we can’t hear them, we don’t know that they are there.”

But capturing species vocalizations is worth the often lengthy pursuit. Young is a marine scientist who studies the ecology of deep-diving whales. Much of her work relates to conservation. Beyond facilitating population estimates, vocalizations can be an important indicator of animal behavior.

“They help us understand what an animal is doing,” says Young. For instance, sperm whales make special “creaks” when they are foraging or capturing prey, which helps scientists identify feeding areas.

“Sound is such a good indicator of ecosystem health,” says Growcott. “We need to be measuring these sounds before it’s too late.”

—Summer Rylander



ENVIRONMENT

The Trouble with the Swamp

YODA, THE LEGENDARY JEDI MASTER who hardly needs an introduction, spent his last days on Dagobah, a swamp-covered planet.

When Luke Skywalker, the protagonist of the *Star Wars* saga visits him there in *Episode V: The Empire Strikes Back*, he finds Yoda sitting on a sunken log carpeted by moss. Yoda is pensive, the end of his walking stick submerged in the shallows, and a mist hovers low above the water. The vegetation is dense, the atmosphere mysterious. Luke is searching for answers, and Yoda is just the oracle he needs.

But it wasn't Yoda, or the twisting plot lines in Skywalker's journey across the galaxy, that Jack Zinnen paid attention to when he recently re-watched this

movie scene. He was interested in the wetland. What role was the habitat playing?

"Whenever I would see wetlands in films, I started noticing patterns," Zinnen, a wetland ecologist for the Illinois Natural History Survey told me. "There's the trope of the weird mystic living in the swamp," Zinnen said, and then one of the "monster that's prowling in the murkiness." In general, he found that swamps tended to be portrayed in film as pretty unhappy places. He began to worry that such caricatures might harm public attitudes and support for protecting wetlands, which have increasingly become recognized as critical resources of biodiversity and targets of conservation over recent decades.

Wetlands became a scapegoat landscape.

To test whether his casual impression of wetlands in film held true over a larger body of work, Zinnen got together with three colleagues and devised a method of systematic analysis.

Using Wikipedia, MovieLens, and IMDb film summary searches, the researchers identified 163 films that prominently featured wetlands, released between 1980 and today, predominantly in English and not including documentaries. For their search, they tried out all kinds of lyrical alternate names for such landscapes: bayou, billabong, bog, delta, fen, flood-plain, glade, lowland, mangrove, marsh, mekong, mire, morass, muck, muskeg, pantanal, quicksand, slough, swale, swamp. They then divided the movies randomly amongst themselves, watched them in their entirety and scored the portrayal of wetlands into categories based on theme or plot elements. The results of the survey were released earlier this year.

What the researchers found mostly confirmed their suspicions: Wetlands were associated with discomfort, misery, or death about half of the time, and positive emotions or outcomes only 10 percent of the time. Often wetlands served as settings of challenge, conflict, or emotional low points for protagonists. Despite their frequent association with despair, Zinnen and his colleagues were heartened to notice that even some of the more negative films still characterized wetlands as productive and biodiverse ecosystems. One third of the films they reviewed showed them as “structurally rich,” though the focus was on fauna rather than flora.

On the positive side, wetlands were also frequently portrayed as places of refuge for oppressed, ostracized people. This latter point has an element of historical truth to it. In the southern United States, European colonial powers frequently displaced Native Americans into wetland areas that were difficult to farm. Some

tribes, like the Seminole Native Americans of Florida grew to thrive in these ecosystems, shaping their culture around the Everglade fauna and flora. People who escaped slavery also often found refuge in wetlands. Notably, the wetlands in the films surveyed were concentrated in the southeastern U.S., with a quarter of them in either Florida or Louisiana.

The negative bias against wetlands is not completely without precedent. Historically, wetlands were places that frustrated cultivation and settlement and hid real physical dangers such as disease and large predators. But attitudes began to change in the mid 20th century as the threats they posed receded and their ecological significance became better understood, according to Zinnen. Then wetland monster films arose as a kind of sub-genre of horror, reinstating a general sense of fear and loathing toward wetlands in the general zeitgeist, he believes. Wetlands became a scapegoat landscape.

“A lot of these negative attitudes toward wetlands are kind of rooted in the old B-movies,” he says. *Creature from the Black Lagoon* is perhaps the most famous of these, he adds. In this monster horror film from 1954, a humanoid amphibian—a presumed missing link between land and sea animals—antagonizes scientists as they explore the Amazon rainforest. The film probed themes of the unknown and the clash between science and nature. The movie epitomizes American attitudes to nature at that time, as “something you squeeze to get as much out of as you want,” Zinnen says.

Zinnen’s study falls short of a prescription for how to change cultural attitudes. But perhaps we can turn to Yoda, who instructs Luke to “unlearn what you have learned.” We could do the same with swamps.

—Elena Kazamia



Macro garden pea flower;;
micro pea pollen, cricket
leg and wing

ARTS

Finding Strange Beauty in Food

FOR PHOTOGRAPHER AND AUTHOR Robert Dash, food is more than a simple pleasure or a source of nutrients. It's an inspiration and the main character in an important story he wants to tell about the planet. In his recent book, *Food Planet Future: The Art of Turning Food and Climate Perils Into Possibilities*, Dash seeks to give people a deeper understanding of the food we find in our grocery carts and on our plates, and how its cultivation impacts the Earth.

Dash has spent decades educating others about biology, natural history, and ecology as a secondary school teacher and naturalist. These are the subjects that have also caught his photographer's eye over the years. In *Food Planet Future*, he set his sights on agriculture.

Using a scanning electron microscope, Dash captures the intricacies of tiny seeds, spores, and scales at the micro level, revealing unexpected shapes and patterns. With a digital camera, he photographs recognizable features of popular foods, ones familiar to the naked eye. Dash then creates mashups of his creations, uncanny compilations that juxtapose distinct levels of scale. Each image is paired with a story that narrates the relationship it has to our tangled global crises of food security, climate change, and biodiversity loss, and to the regenerative strategies that could help pull us back from the brink.

—Katie Neith

Photos by Robert Dash



Macro quinoa leaves, seeds,
and flowers; micro quinoa
starch granules





Macro corns,
micro corn
tassel

The background of the cover is a blurred photograph. On the left, a portion of a tree trunk with light-colored, textured bark is visible. On the right, the back of a wolf's head and its thick, brown and black fur are partially shown. The central area is a soft, out-of-focus greyish-brown.

HOWL

The dark side of wolf reintroduction

BY KEVIN BERGER





DIANE BOYD WALKED ALONG the North Fork of the Flathead River. It was a clear blue summer day, and the wolf biologist relished being in this Rocky Mountain valley in northwestern Montana. She set foot here 45 years ago to track the first known gray wolf to wander into the western continental United States from Canada in decades. Humans had exterminated the last of them in the 1930s.

The river wove through pine, aspen, and willow trees that rose along the edge of a sprawling grass meadow. The mountain peaks in the distance were topped with snow. Boyd grew up in suburban Minnesota, where she was the neighborhood kid who could be found at the wild edges of the subdivision putting caterpillars in jars.

"I always wanted to go more and more wild in my life—wildlife, wild places—and it doesn't get a lot wilder than here," Boyd said to me last summer, as we walked through the quiet meadow.

At age 69, dressed in jeans, running shoes, and a T-shirt picturing a dog lazing on a lake pier, Boyd seemed very much the innately independent biologist who settled here at age 24. She spoke with a directness that had little room for sentimentality. The meadow area is called Moose City and was originally a 1910s homesteader ranch with six log cabins. Boyd lived alone in one of the tiny cabins without electricity or running water for 12 years.

Wolf reintroduction is a huge and messy paradox, a noble intention to save the wolf soaked in the wolf's own blood.

She was the rare woman among the congeries of male wildlife biologists, loggers, and hunters who traversed the valley in the 1980s and '90s. She showed me the path where two loggers snuck up on her cabin one night, asking to come inside. "Step out where I can see you," Boyd told them, staring down the barrel of her rifle she used to hunt deer and elk. The men turned and left.

Boyd gained a reputation as the elusive wolf biologist with a preternatural ability to find and trap wolves in the forest. Boyd used traps with smooth steel jaws that clamp around a wolf's leg when they step on a spring-loaded disc buried in a spot where a wolf might step, like around a big rock in a deer trail. Shock and stress rattle through wolves' bodies when the jaws snap on their leg. "It's painful and terrifying for them," Boyd said. "They're top predators. They've never dealt with something they can't fight or conquer. Trapping is never kind." Boyd apologized to each wolf before tranquilizing and fitting her or him with a radio-transmitter collar.

Boyd tracked wolves in the heat, snow, on foot, skis, and a small plane with bush pilot Dave Hoerner. Her research revealed where wolves traveled and dened, what they ate, when they stayed with their packs or went solo, how they affected other animals, and how they died. She couldn't be bothered with humans. (In 2003, a *Sports Illustrated* reporter spent 56 days trying to track Boyd down for an interview.)

She grinned when I mentioned her notoriety. "I was a complete misanthrope," she said. "I didn't have time to pussyfoot around socializing. I would rather just do my work. But I've mellowed and am much more social now."

Last September Boyd published her first book, a memoir, *A Woman Among Wolves*. She captivantly details her life in the wild, offering as close to a wolf's-eye view of the Northern Rockies as we're likely to see.

Later in the book, as she takes stock of the state of wolves today, she delivers a stinging claim: "Wolf recovery is all about people and very little about wolves."

In 1995, after an epic political battle between conservationists and conservative politicians, the U.S. Fish and Wildlife Service, the federal agency that manages America's wildlife and wildlands, transplanted a total of 12 gray wolves from Canada into Idaho and Yellowstone National Park. At least twice that many had taken up residence in Montana on their own.

The gray wolf is the species of wolf most of us imagine a wolf to be, in reality and dreams, with its commanding body and thick rich coat, slender and strong legs, speeding across a meadow with its pack mates to take down an elk. It's the biggest wolf species of all.

"They're just incredibly clever and social animals," Boyd said. "They feel things, they care, they're playful." Wolves form packs that are usually extended families—a breeding male and female, offspring, siblings. Sometimes they adopt. "They organize just like people," Boyd said. "They hunt in packs because they're not efficient as a single predator. They need to cooperate, communicate, and maintain a social order. They kill other wolves to protect their family and resources. They defend their territory to the death. It's not an easy life. Wolves on average live a little over four years."

Today, about 2,700 gray wolves range across Montana, Idaho, and Wyoming, raising new generations of pups and delighting observers, who in 2022 spent \$82 million in the greater Yellowstone area of Wyoming and Montana just to watch wolves.

As wolf reintroduction marks its 30th anniversary this year, Defenders of Wildlife, an environmental group instrumental in ushering it into law, calls it "one of most celebrated ecological experiments in history and an extraordinary conservation victory." A veritable library of books and articles published in the past three decades tells a similar story.



WOMAN AMONG WOLVES Diane Boyd, with Sky and Benny, at her cabin in remote northwestern Montana in 2024. In the surrounding forest, Boyd has tracked and studied wolves for more than 40 years.

Boyd, however, is telling a different one.

“I am absolutely certain wolves would be here in the numbers they are now just through natural dispersal,” Boyd said to me. “But natural recolonization was effectively killed by reintroducing the wolves.”

Once the government stepped in, Boyd said, the Westerners who hated wolves had a reason to hate them even more. That led to angry protests and dead wolves.

“Humans don’t like to have stuff foisted on them,” Boyd said. “It’s always perceived as a black-helicopter government—government forced on them, watching them. If wolves came on their own there would have been higher social tolerance of them. They would be better off now if they’d never been introduced.”

I actually met Boyd once before, in 1989. Plans to return wolves to the Rockies had been stirring in the environmental news. My brother Todd and I arrived here to string together the story, meeting ranchers and hunters who told us how much they hated the idea because wolves would devour cattle, sheep, and elk.

We lived in San Francisco and tried to be objective but apparently didn’t do such a great job of it. The head of the Montana Stock Growers Association said to us, “Well, boys, if you want wolves so much, why don’t you let them go in Golden Gate Park?”

We managed to coax Boyd into an interview one night with the help of her friendly colleague, Mike Fairchild. Their research was part of the Wolf Ecology Project at the University of Montana at Missoula, where Boyd had received her master’s degree in wildlife biology and later her Ph.D.

Boyd informed us that hunters and ranchers drummed up opposition to the wolves by exaggerating their numbers and the number of pups they could bear. Boyd’s accurate counts and insights into wolf biology were golden to early reintroduction advocates.

Back then, I had assumed Boyd was on the side of wolf reintroduction. So, I was surprised to learn many years later that she had never supported it. As a nature lover from a big city—Boyd calls us “greenies”—I had taken it for granted that wolf reintroduction was a progressive act, restitution for Americans having slaughtered a million and more wolves in the 1800s and 1900s. Without the wolf, a predator key to natural ecological relationships, the American wilderness was diminished.

KEVIN BERGER

THE DEBUT Bruce Babbitt (far right), Secretary of Interior in 1995, helps carry the first wolf for reintroduction into Yellowstone. Babbitt's endorsement of reintroduction, after years of political battles over it, was critical.

After many conversations with Boyd, key architects of wolf reintroduction, wolf scientists, animal trappers, ranchers, animal welfare experts, and environmental lawyers, I have to say my view now is not so green. I learned how wolves suffered and died in the course of reintroducing them.

Built on the foundations of conservation and science, shaped by industry and politics, wolf reintroduction is a huge and messy paradox, a noble intention to save the wolf soaked in the wolf's own blood. For the 2,700 wolves that roam the Northern Rockies today, data shows at least five times as many have been killed in the past three decades. From 2021 to 2023 alone, hunters and state wildlife managers legally killed more than 1,500 wolves in Idaho, Montana, and Wyoming.

Was Boyd right? Would the wolves be better off now without introduction?



THE FIRST WOLF that wandered alone into Montana 46 years ago was doing what her kin had done for millenia, branching out from her family to find a mate and territory to call her own. She didn't know there was a border between Canada and the United States. The forest that ranged across both countries was the same place to her.

She was, after all, a wolf.

For years, the wolf traveled hundreds of miles on her own. She investigated "beaver lodges, deer sites, coyote urinations, river bottoms, and mountain ridgelines," Boyd wrote in her memoir. After three years of roaming alone, the intrepid wanderer found a mate. The pair's sleeping sites in the forest showed they curled up together, and in the spring of 1982, they had seven pups.

In the following hot summer, the male was accidentally snared in a trap set by grizzly bear researchers. He died the next day, likely from the heat and stress of the capture, Boyd believed. The "plucky and lucky" single mom provided for her pups alone. They survived the humans populating the land around them and had litters themselves in the Northern Rockies.

The growing families settled in forest areas like river drainages where they found plenty of elk, deer, moose, and bighorn sheep to feed on. And sometimes, but rarely, when wolves were on the hunt, they came across a ranch and took down a steer calf or lamb.

Some long-distance sojourners walked from northwestern Montana to Idaho to establish new packs. One female traveled more than 500 miles from Montana to a new territory in British Columbia. Had she traveled south instead of north, Boyd wrote, she would have settled about 100 miles south of Yellowstone. She could have been hugging the border of Colorado.

In 1985, a female wolf with a creamy white coat was traversing the mountains surrounding the Moose Creek meadow, searching for a mate. She found him and by May that year had built a den just north of Montana's Glacier National Park, where the white wolf nursed and played with her seven new black pups. She had five more pups the next year, this time inside the park.

The white wolf was canny and intelligent. Boyd used her best tricks to try and capture her. She wanted to replace her radio collar before its signal failed. But the "white phantom" kept outwitting her. The white wolf would paw the

"Wolf recovery is all about people and very little about wolves."



IN A HEARTBEAT Ed Bangs, who directed wolf reintroduction, says politicians would have shut it down in a heartbeat if it didn't include an amendment that altered the Endangered Species Act.



dirt around Boyd's traps, expose the buried piece of metal, and pull the trap to the ground, sometimes without springing it. She would defecate to the side of the trap, "proclaiming this turf as hers," Boyd wrote.

Family dynamics in a wolf pack never stand still. In 1987, the white wolf was deposed as the breeding female from her pack. Her allure, though, hadn't faded, and in just months she found a new mate and gave birth to her third litter of pups. Something roiled her previous pack, and some of the members rejoined the white wolf to help raise her new family.

In September that year, five of the white wolf's pups ran afoul of Canadian hunters and poachers, who shot and killed them. The remaining wolves who had lived with the white wolf fled south to their old pack in the sanctuary of Glacier National Park, "seemingly understanding the danger of the British Columbia wolf hunting season," Boyd wrote.

The white wolf, solitary again, wandered for years through the Northern Rockies. She was 9 years old in 1992, elderly for a wolf, and lingered in the foothills near a forestry camp in Alberta, Canada, where an outfitter shot and killed her.

Before she died, the white wolf trotted across the Moose City meadow toward Boyd's cabin. She locked eyes with Boyd and then turned around and trotted back in the direction she had come from, disappearing into the willows. Boyd wondered why the white wolf had come. Did she recognize her scent from her traps? Boyd decided the white wolf had "dropped by to let me know that she was still out there, still in control, and still smarter than me."

WHILE WOLVES WERE DOING wolf things in the Northern Rockies, humans had big ideas for them.

For wildlife conservationists, bringing back the wolves would restitch the ecological tapestry of animal and plant species in the areas from which the wolves had been excised, especially the iconic Yellowstone, the nation's first national park.

The vision of the wolf's ecological role was inherited from naturalist and writer Aldo Leopold. In his posthumous 1949 book *A Sand County Almanac*, Leopold told a wistful tale of his awakening to the wolf as an embodiment of interwoven nature.

Leopold was a hunter. One day he and his companions shot a wolf, as they had done many times before. “We reached the old wolf in time to watch a fierce green fire dying in her eyes,” Leopold wrote. “I realized then, and have known ever since, that there was something new to me in those eyes—something known only to her and to the mountain.”

Leopold, educated in forestry, wrote that without a predator like the wolf to take down elk and deer (both are a prime wolf meal), the ungulates would overgraze and impoverish “the flora, from wildflowers to forest trees,” in their habitats. This was visibly true in Yellowstone in the 1940s, where “the elk are ruining the flora.”

Meanwhile, conservative politicians had their own vision. The restoration of wolves would be a major affront to their constituent developers, ranchers, and hunters.

In 1985, Wyoming Representative Dick Cheney read an interview in the *Casper Star-Tribune* with National Park Director William Penn Mott. Mott said wolf reintroduction would “add a great deal to the natural values of Yellowstone and balance the ecosystem.” Cheney immediately wrote to Donald Hodel, the secretary of the interior, Mott’s boss: “I just want you to know that I am every bit as committed to preventing government introduction of wolves as Bill Mott is determined to put them there.”

Republican Representative Ron Marlenee of Montana opted for the rhetorical dig. “Will the wolf be just another ploy by ‘green bigots’ to block development in Montana?”

Those anecdotes come from the book *Wolf Wars* by Hank Fischer, the definitive insider account of the political machinations behind introduction. Fischer was the Northern Rockies representative of Defenders of Wildlife. He worked unflaggingly on behalf of reintroduction for 15 years, including facing off with the conservative politicians in their Capitol Hill offices. Early in the battles he instituted a key strategy, the Wolf Compensation Fund, a pool of money from donors to reimburse landowners for livestock killed by wolves.

For Fischer, like the Yellowstone managers who set wolf reintroduction in motion in the 1970s, ecological restoration was the Holy Grail. Fischer explained in *Wolf Wars* that he was inspired less by the wolves themselves than by a vision of Yellowstone where you could experience “the intricate interplay of wolves; elk; aspen; beetles; ravens; fire; weather; and people, the aspect of the equation all too often overlooked.”

Like all wars, victory was going to depend on compromise. In this case the compromise involved the Endangered Species Act.

The act was passed by Congress with nary an objection and signed into law by President Nixon in 1973. The politically savvy Nixon was

The
“plucky
and lucky”
single mom
provided
for her
pups alone.







no environmentalist, but his statement when he signed the Endangered Species Act underlined its central goal: the preservation of “the rich array of animal life with which our country has been blessed.”

The Endangered Species Act was riding a wave of environmental good will on both sides of the political aisle that practically seems naïve today. It followed the Clean Air Act, Clean Water Act, and the National Environmental Policy Act into law. The lawyers and scientists who wrote the Endangered Species Act, and the lawmakers who sold it on Capitol Hill, saw it as recompense for animals rendered extinct by “economic growth and development untempered by adequate concern and conservation.”

The gray wolf, victim of inadequate concern for conservation throughout America’s history, was added to the Endangered Species List in 1994.

Environmental law scholar David Takacs, an emeritus professor of law at the University of California, College of the Law, San Francisco, told me he considered the Endangered Species Act “the most radical statute ever passed by the U.S. Congress of any kind. It said the value of non-human species is incalculable, and the needs of those species take precedence over the needs of humans in the United States.”

HOLDING PEN A wolf sprints from its shipping container into a holding pen in Yellowstone. Wolves were caged in the pens for several weeks to acclimate to the scents of their new habitat in the park.

“We messed up. I mean, we’re not perfect. We made mistakes.”

The Endangered Species Act sought to save a species by also protecting its critical habitat. Development plans that jeopardized critical habitat were subject to review by the Department of the Interior. That was where the radical law met its match.

The ink on the Endangered Species Act was barely dry when the critical habitat distinction made headlines. A tiny, endangered snail darter fish was in danger of losing its habitat if a dam in Tennessee was built. The law held up construction for two volatile years.

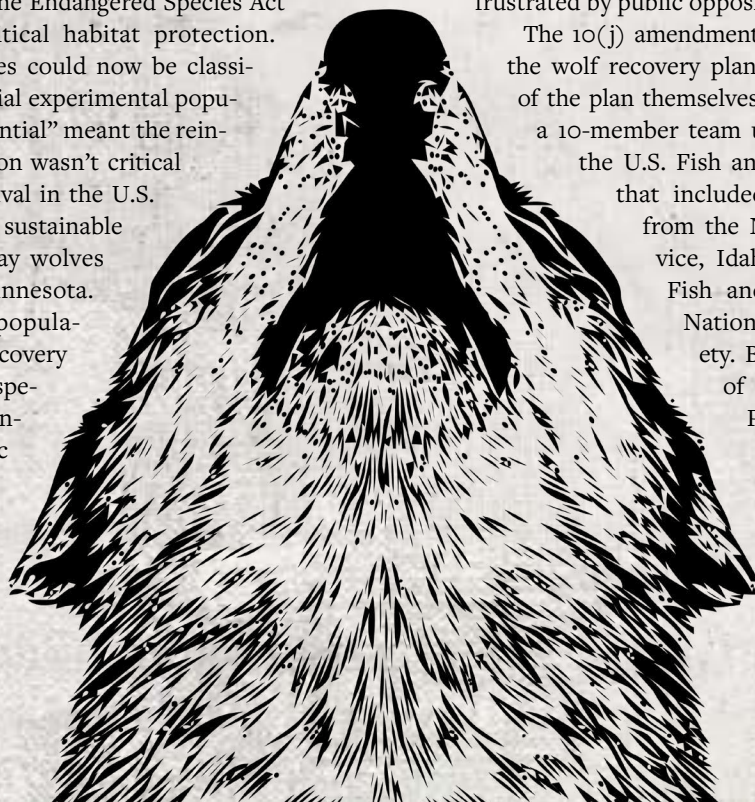
Never mind that Congress managed to get the snail darter exempted from the Endangered Species List, the dam was built in 1979, and decades later a scientist determined the snail darter wasn’t, technically, even a snail darter. The dam brouhaha generated bad vibes for the critical habitation distinction and dissolved much of the bipartisan good will for the Endangered Species Act.

In 1982, Republicans in Congress sealed an amendment into the Endangered Species Act that defanged critical habitat protection. Endangered species could now be classified as “nonessential experimental populations.” “Nonessential” meant the reintroduced population wasn’t critical to its overall survival in the U.S. Indeed, there were sustainable populations of gray wolves in Alaska and Minnesota. “Experimental population” meant that recovery of an endangered species would be confined to a specific management zone.

The new amendment, known as “10(j)” for its section listing in the Endangered Species Act, undercut the federal power of the Act by inviting state wildlife agencies, with their own agendas, into the room to shape wildlife management plans. It also overruled the section of the Endangered Species Act that prevented citizens from “taking”—that is, killing—an endangered species. Landowners whose livelihoods were threatened by an endangered species could now be permitted to kill the animal themselves.

Takacs, coauthor of a journal article, “Wolf Law,” which pored over all the legal actions behind wolf reintroduction in the Northern Rockies, said it was likely the 10(j) amendment was added with wolves in mind. A Senate report on the amendment mentioned wolves as an example of an experimental population that could be killed if “depredations occur or if the release of these populations will continue to be frustrated by public opposition.”

The 10(j) amendment was inserted into the wolf recovery plan by the architects of the plan themselves. They constituted a 10-member team under the aegis of the U.S. Fish and Wildlife Service that included wildlife experts from the National Park Service, Idaho Department of Fish and Game, and the National Audubon Society. Bob Ream, founder of the Wolf Ecology Project, was also on the team. Ream was opposed to



THERE WILL BE BLOOD

Carter Niemeyer, with an animal trap, was sent to Canada to build relationships with local wolf trappers who would capture the wolves for reintroduction. It was a bloody affair.



reintroduction and favored allowing the wolves to return on their own, as his mentee, Boyd, would favor after him. Ream was outvoted.

The decision by the recovery team to include the 10(j) amendment flipped the Endangered Species Act on its head, Takacs said. “The Endangered Species Act is supposed to be about managing people for the benefit of endangered species. But the recovery plan showed the Fish and Wildlife Service was about managing wolves for the benefit and convenience of people.”

This was Boyd’s point. The welfare of the wolves would have been better served if they were allowed to return on their own, shielded by the unexpurgated Endangered Species Act. With the 10(j) amendment, Boyd said, “Wolves could now be shot for killing livestock. If the wolves walked in on their own, nobody could have touched them.”

SARCASM WAS CREEPING INTO Ed Bangs’ voice. “‘Oh, if the wolves had just come on their own, people would have been so accepting, and there wouldn’t be all this controversy.’ That’s a fairy tale.”

The gregarious Bangs, with a deadly dry sense of humor, greatly admires Boyd. When he arrived in Montana in 1988 to take charge of wolf recovery for the U.S. Fish and Wildlife Service, he said, “I realized the only people who knew anything about wolves were Diane and Bob [Ream] and Mike Fairchild of the Wolf Ecology Project.”

Boyd worked briefly for Bangs in the late ’90s, monitoring wolves and working with ranchers to resolve conflicts with wolves without killing them, such as installing fences with flapping flags and noisemaking devices that deter the wolves. They have also been coauthors on academic papers. Bangs just didn’t buy Boyd’s view that wolves would have survived on their own.

Bangs oversaw reintroduction in the Northern Rockies for 23 years. In the late ’80s he led more than 500 community meetings, mostly in rabid anti-wolf counties, the voice of pragmatism in a din of anger. No, wolves don’t attack people; no, wolves that came down from Canada aren’t mutant giants; no, wolves won’t wipe out the elk and deer for hunters; and yes, wolves can be managed to protect ranchers’ livestock (with some killing).

During the meetings, Bangs told me from his home in Helena, Montana, “I can’t tell you how many people walked up to me and bragged, ‘My granddad killed the last wolf in this county. And Granddad was carried through the streets on a chair, he was a hero.’ That’s the culture here. It’s never gone away. So, are you going to tell these people they can’t do anything when a wolf comes into their backyard? Those wolves are dead. People only obey laws they think are fair. You are going to have lethal control of wolves whether it’s legal or not.”

What’s more, the reintroduction train was out of the station. There was no turning back. The train was also now fueled by plenty of other people who were excited about the opportunity to see wolves in the wild, or just knew they were out there, reviving nature. The amendment that defanged the Endangered Species Act provided final passage.

“You have to understand, these guys could have stopped this thing any time,” Bangs said, referring to the anti-wolf congressmen in Wyoming, Montana, and Idaho. “If the environmentalists had argued in court, ‘We should reintroduce wolves as fully endangered, with no control for depredating wolves,’ reintroduction would have never happened. Those guys would have killed that in a heartbeat.”

Begrudgingly, the conservative congressmen backed off. Wolves would be reintroduced as experimental populations in three management zones: northwest Montana, central Idaho, and greater Yellowstone, which included the park and contiguous areas of Idaho and Montana. In 1994, the Department of the Interior signed off on the recovery plan; a final battle against wolf opponents in a Wyoming district court was won.

The stage was set for bringing wolves back to the Northern Rockies.

ENTER CARTER NIEMEYER. Wildlife Services is a federal agency that may not be well known outside rural America. It’s the agency that fields calls from landowners who report a wild animal—wolf, bear, coyote, mountain lion, fox—has killed their livestock (or dogs). An agent is then dispatched to capture and relocate the predator or, when authorized by a U.S. Fish and Wildlife Service boss like Bangs, kill the animal.

The federal government has granted the agency the power to kill wild animals since it was founded in 1885. During America’s Westward Ho days, the agency itself helped wipe out the wolves. Since then, it’s killed millions of wild animals across the country. In the past 30 years, it’s killed hundreds of wolves.

At the dawn of wolf reintroduction, Niemeyer was the western Montana district supervisor of Wildlife Services, then called, less

TRAPPED Diane Boyd always apologized to wolves after trapping and tranquilizing them before fitting them with a radio collar. “Trapping is never kind,” she said.



euphemistically, Animal Damage Control. He had trapped and killed thousands of coyotes, foxes, elk, moose, and practically every other animal that moved in the wild. He hadn't killed a wolf yet. He would kill 13 before his career was over.

Niemeyer, however, was known as the most scrupulous trapper in the business. He didn't just take ranchers' word that a wolf or bear killed their livestock and sign off on a permit so the rancher could be reimbursed. He knew how to identify the signs of each predator's means of killing or whether livestock had accidentally killed themselves from tangling with a fence or died from disease or infection. Niemeyer made the final calls for the Defenders of Wildlife's reimbursement program.

Niemeyer and Bangs quickly bonded in the wolf recovery drama. The folksy Niemeyer also has an ingratiating sense of humor, evident in his 2010 memoir, *Wolfer*. It could have been called *Confessions of an Animal Killer* for its disarming candor and wistful tone of penitence. However, I must say, as a greenie, even a reformed one, Niemeyer's—and Bangs'—matter-of-fact manner of describing killing wild animals can be a little alarming.

As wolves began finding new homes in the Northern Rockies, the unflappable Niemeyer brought calm to landowners who demanded that he come out to their ranches, and track down and kill the wolves devouring their cattle and sheep. Most of the alarms were set off by hot air. During the first few months of 1994, Niemeyer did necropsies on more than 100 sheep, cattle, and horses that landowners claimed had been killed by wolves. Niemeyer found that only five of the animals—four

calves and a lamb—were wolf victims. (A report by the Humane Society of the U.S. found that wolves, based on data from 2015, killed 0.04 percent of cattle and sheep in the Northern Rockies.)

Niemeyer's and Bangs' first real challenge together came in 1989, when the duo arrived at a northern Montana ranch where the landowner insisted that a pack of wolves had killed four of his calves. "No, sir," Niemeyer said, after examining them. This time the rancher wouldn't buy Niemeyer's evaluation, and didn't keep his anger to himself. "The local newspapers had convicted the wolves, and so had the neighbors for miles around," Niemeyer wrote.

Bangs held firm and didn't order the wolves to be trapped or killed. Not long afterward, the pack did attack a few livestock. This time Bangs and Niemeyer trapped them—two adults and two pups—and shipped them to the sanctuary of Glacier National Park. It was September, and Bangs miscalculated that the pups could find food—small game and carrion—that late in the year. "Both pups starved to death," Bangs said.

Bangs trapped the adult male to move him. His colleagues (not Niemeyer) bandaged



the wolf's damaged foot and released him with the bandage on. "That was a rookie mistake, but a horrible mistake," Bangs said. "I saw that his leg was infected and so the main thing to do was euthanize him. So I shot him with the rifle I borrowed from the rancher who was with me. I was sad. You know, we screwed up. We messed up. I mean, we're not perfect. We made mistakes."

When wolf reintroduction finally got the green light in 1994, Niemeyer was the person for the job to bring the wolves down from Canada.

Bangs first sent an assistant to coordinate the U.S. Fish and Wildlife Service plans with Canadian trappers. The Service had already signed a contract with a local Canadian to trap wolves for \$2,000 each—and not kill them. But when Niemeyer got to Alberta in November, he found the assistant had done little to keep in contact with the trappers, and his office in a motel was a mess.

"I was alarmed at the lack of preparation for this historic moment in conservation," Niemeyer wrote in *Wolfer*. As "far as I could tell, the Fish and Wildlife Service had put almost no thought into how we'd actually obtain the wolves."

Niemeyer drove to the dense forest cabin of the hired Canadian trapper himself. The trapper and two of his buddies were angry because they hadn't heard from the Fish and Wildlife Service in weeks. They had already captured nine wolves. When they didn't hear from the U.S., they killed all nine, skinned them, and sold their hides for about \$400 each.

The head trapper didn't believe Niemeyer was there to finally pay them. "Why should I believe another government biologist in a government truck with government plates," he told Niemeyer at the time. The trappers wanted Niemeyer to prove himself. They brought in two big dead black wolves from their pickup truck and challenged Niemeyer to a race to see who could skin a wolf the fastest.

The contest was held in the head trapper's dining room, and Niemeyer held the dead and bloody wolf in his lap. It had been shot in the head, presumably to end its struggle in the trap. Niemeyer and one of the trappers pulled out their knives and began their macabre contest. The head trapper's wife brought them glasses of wine. After a couple of hours, with his clothes soaked

"I'm just saying, if you don't have the stomach for dead wolves, reintroduction ain't for you."

in the wolf's blood and feces, Niemeyer finished first. He and one of the trappers carried the fur-less carcass to the back door and tossed it on the icy deck. To the trappers, Niemeyer could now be trusted. "He's one of us," the head trapper said to his buddies, as Niemeyer recounted in *Wolfer*.

The next day, the Canadians trapped three wolves. They weren't using leg traps but neck snares made of a thin, strong cable attached to tree trunks that lassoed the wolves around the neck and stretched tight as they tried to escape. The U.S. Fish and Wildlife Service contract stipulated that the neck traps have metal stops on the cables that snare tight enough to hold the wolf by the neck but not strangle it to death.

One trapped wolf was an adult female silver wolf whose weight was on the slight side. The cable was so tight around her neck that Niemeyer had to snip it off with cable cutters. She was limp and freezing and the corners of her mouth were deeply cut from biting the long stem of her noose. The other two traps held her pups. Niemeyer freed one of them. The snare had tightened around her shoulder and not her neck, saving her from being strangled. Her leg was badly cut. The other pup was dead and frozen in the brush. The next day, with mother and her lone pup in holding pens, Niemeyer called a vet to suture the cuts on their lips and legs.

Over the next year, Niemeyer said, the operation ran better. But not for the wolves. They were still being traumatized when captured in traps and put in holding pens. The wolves often cracked and broke their teeth on the bars in pens, trying to escape. Niemeyer and his colleagues also shot wolves with tranquilizer darts

from planes as the wolves ran through the forest. Sixty-six wolves in total were captured and then released in Yellowstone and Idaho in 1995 and 1996.

One day in 1996, Niemeyer stood by the pen of a particularly aggressive wolf. The wolf made long eye contact with him. “The message was clear: He was fed up with people bothering him,” Niemeyer wrote.

The wolf was flown to Missoula, Montana, where biologists examined his health and penned him, before he would be trucked to Idaho for release. One of the wildlife biologists slipped ice under the pen’s sliding door for the wolf to lick and the wolf lunged and bit the biologist’s finger. As government policy required for any wolf who bit a person, the wolf was killed and tested for rabies. It was negative.

Last September, talking with Niemeyer, I remarked that getting the wolves back to the Northern Rockies literally began in a pool of wolf blood in that trapper’s dining room. “Bingo,” he said. “It’s symbolic, and an irony I’ve had to live with. It was an ugly side of the business that needed to be done. I’m just saying, from my 33 years in the field, if you don’t have the stomach for dead wolves, reintroduction ain’t for you.”

DOUG SMITH SIGHED. Smith was the project leader of wolf reintroduction and wolf management in Yellowstone for 28 years. He retired in 2022. With his bushy walrus mustache, he is the quintessential field scientist, a genial and sympathetic guide to the wolves in Yellowstone, whose unique personalities he got to know over his many years in the park.

He wasn’t agitated about Niemeyer’s bloody account. In “How Wolves Returned to Yellowstone,” published in a 2020 book of scholarly essays, *Yellowstone Wolves*, co-edited by Smith, he and his coauthors recommend Niemeyer’s book *Wolfer* “for a personal account of the challenges” of retrieving the first wolves from Canada.

Rather, it was Boyd’s conviction that wolves would have repopulated Yellowstone on their own that had Smith “animated,” he said.

Like Bangs, Smith wanted to impress on me that he admired Boyd, and they were friends. And he agreed that wolves did travel hundreds, even thousands of miles through the Northern Rockies, and did reach Yellowstone from northern Montana. But the individual wolves were shot, he said, before they could form new packs.

Smith was all for the idea of natural recolonization. It has been successful in other states. While humans in

COUNTERPOINT

Doug Smith, former leader of wolf reintroduction in Yellowstone, praised his friend Diane Boyd for her pioneering research. But he refuted her view that wolves could have recovered on their own.



the 1900s were finishing off wolves in the Western U.S., some wolf packs survived in northern Minnesota. Wolves likely from Minnesota returned on their own to Wisconsin in the '70s and Michigan in the '80s. Both states host wolf populations today. In those three states, Smith said, "it's continuous forest. Wolves aren't as visible in forests. They have places to hide. There are corridors connecting Minnesota to the Upper Peninsula Michigan and northern Wisconsin. So natural recovery was the best decision there."

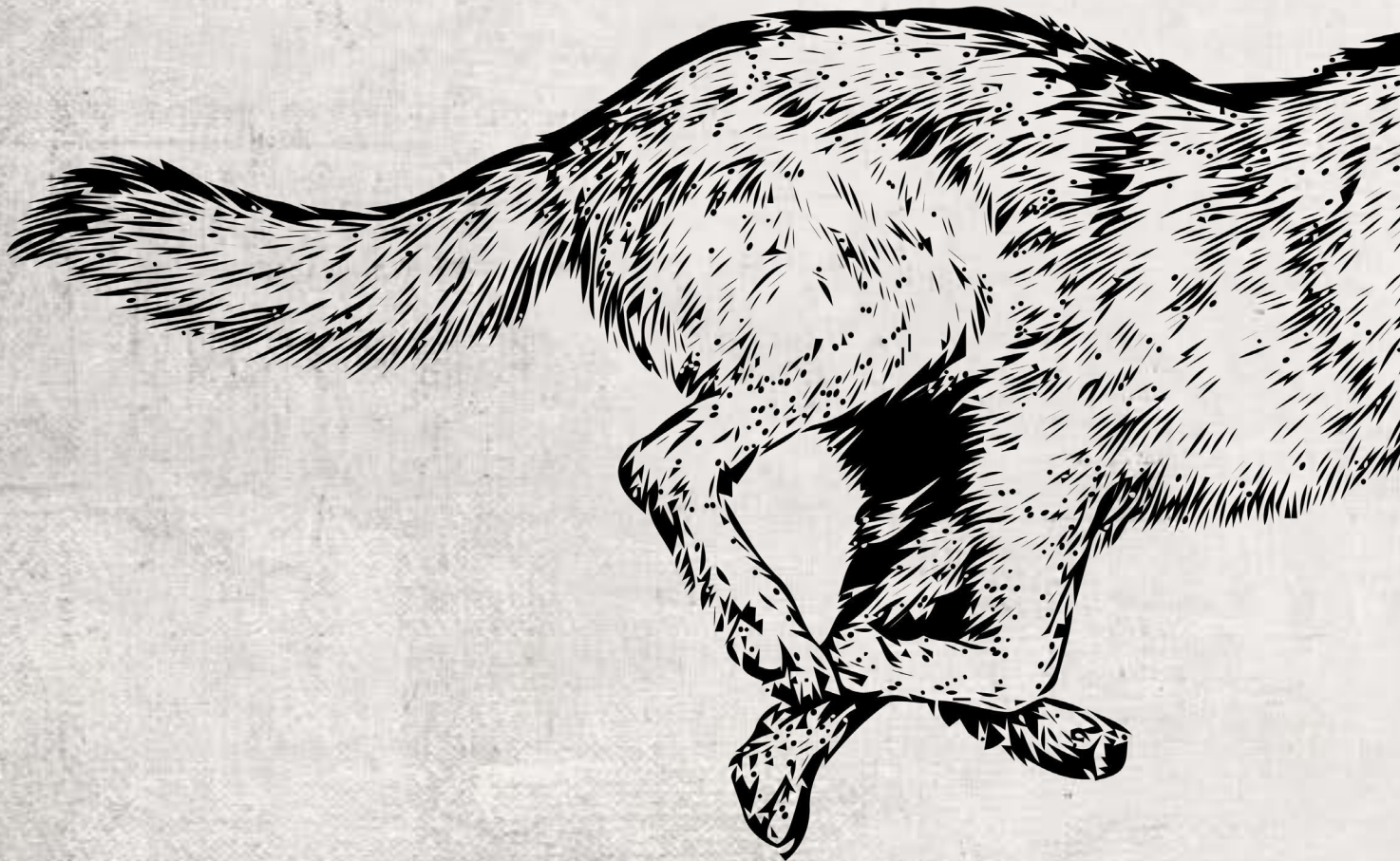
But not a good decision for Yellowstone. The GYE (Greater Yellowstone Ecosystem), comprising the park in Wyoming and contiguous lands in Montana and Idaho, "is an ecological island surrounded by a sea of humanity," Smith said. "When you hit the edge of the island, you go into roads, private land, and open country, and wolves get shot in open country. It's a human-dominated landscape with guns and cars everywhere—a gauntlet the wolves have to get through." And they haven't got through it, Smith said. From 1995 to 2024,

"we have not documented wolves making it to the GYE from where Diane says they would have come from."

Boyd had said the 10(j) amendment to the Endangered Species Act, which permitted landowners to shoot wolves themselves, was ultimately detrimental to their recovery. Smith disagreed. He claimed the amendment "made reintroduction more palatable and acceptable to the public."

"Diane is right," said Adrian Treves, a professor of environmental studies at the University of Wisconsin-Madison, where he founded the Carnivore Coexistence Lab. Treves explained to me that the 10(j) amendment is a forerunner of current laws that grant state wildlife agencies the right to cull wolves and the public the right to hunt them. Legalized wolf killing, Treves said, has not made the public more tolerant of wolves—namely the part of the public likely to do the killing, landowners and hunters.

"With legalized killing, the government has sent a signal to would-be poachers that wolves have little



Hunters can now trap wolves with neck snares, use bait to lure them, kill them with crossbows or handguns.

value,” Treves told me. What’s more, “People feel like, ‘OK, it’s more acceptable now to kill wolves because the government’s doing it. And if they don’t do it, I’m going to help them out.’”

In 2001 and 2004, Treves and colleagues mailed a total of 1,900 surveys to Wisconsin residents who lived in wolf country, the north part of the state. Then they recontacted 650 of those residents in 2009. During that time, wildlife agencies implemented a program to cull wolves who had been attacking livestock (and dogs). By 2009, Treves’ survey participants showed an increase in their fear of wolves,

support for culling them, and inclination to poach them, that is, illegally kill them without a government permit.

Treves and colleagues drilled deeper into poaching in a data analysis of wolf information in Wisconsin and Michigan. From 1995 to 2012, both states went through periods when wolves were alternately protected and culled. Dur-

ing the periods when state wildlife managers killed wolves because they were preying on livestock, Treves and his colleague Guillaume Chapron, an ecologist at the Swedish University of Agricultural Sciences, calculated that the normal population growth rate of wolves had slowed down. Treves and Chapron examined data that could provide alternative biological explanations for the decline, such as a decline in wolf pack sizes, or wolves leaving the state, but that turned up empty. That left illegal killing as the best

explanation. The study, Treves and Chapron pointed out, is focused not on wolf habitat in the wilderness but in a “human-dominated matrix.”

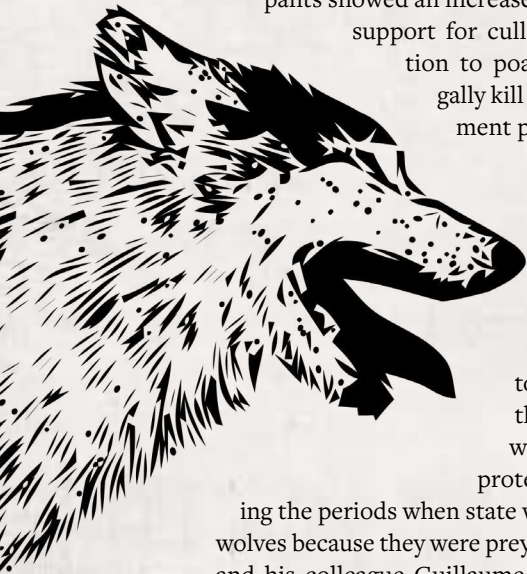
Considering the explosion of wolf hunting in the Northern Rockies, it’s hard not to think Treves got it right, that government laws that sanction wolf killing have led to more bloodshed than even Niemeyer could have imagined.

It’s the irony at the heart of reintroduction that it has given trappers and hunters so many wolves to kill because it was so successful. And that success was due to “gold star, rock-solid science,” Bangs said. Wolves were captured in different areas in Canada because that would ensure that when the wolves hooked up in America, they would establish genetic diversity, key to their health and longevity. Genetic studies have shown that inbreeding among wolves (and many other animals) in an insular area sets up a high probability for the population’s extinction.

As the reintroduction plan spelled out, wolves would be considered recovered when 100 wolves inhabited each of the three recovery areas—Montana, Idaho, and Wyoming—for at least three years. The wolves met that goal in practically no time. By 2002, they had more than doubled the recovery goal, and 663 wolves traversed the Northern Rockies.

In 2011, wolves in Montana and Idaho, whose populations had grown past recovery requirements, were “delisted,” removed from the Endangered Species List. In Wyoming, court battles between wildlife agencies and conservationists broke out, and wolves were listed and delisted several times. Agencies got the upper hand in 2017, when wolves were delisted and public “harvesting” of them could resume. (Hunting has always been banned inside Yellowstone.)

The initial recovery plan gave states a place at the federal table to manage the wolves. Delisting moved



“Let’s just let nature take its course. Let wolves be wolves.”

them to the head of the table. Today, state wildlife departments declare they manage wolves “for a stable, self-sustaining population in suitable habitat for conservation purposes and harvest opportunity,” reads the current Idaho plan. The number of wolves in Idaho, Montana, and Wyoming do exceed the federal targets that consider them recovered. But culling the wolves, which the states do, mostly with legal hunting, stems from politics not science, say Boyd, independent conservationists, and reintroduction’s architects.

“Cattle politics run everything here,” Bangs said, referring to Montana. “There were and are professional scientists of the highest caliber in the state agencies in Montana, Idaho, and Wyoming. But politics is so polarized and bitter now. State game managers can’t make scientifically valid judgments because they’re overridden by some guy who likes to hunt.”

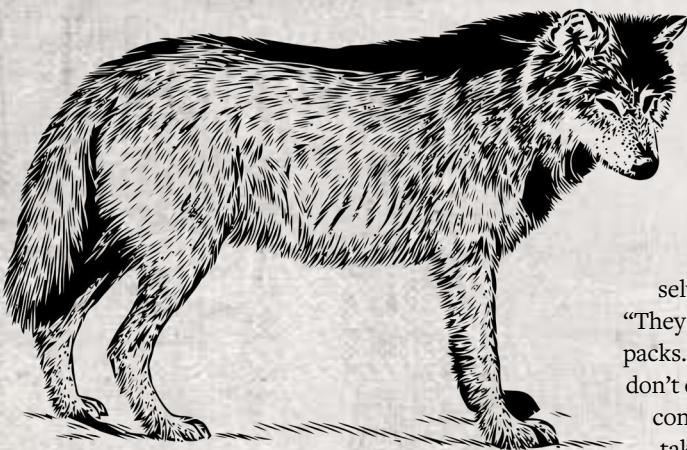
State game departments bank on wolf hunting licenses. From 2009 to 2023, wolf licenses

generated \$5.4 million for Montana Fish, Wildlife, and Parks, about 10 percent of its total hunting license revenue. Montana’s current governor, Greg Gianforte, a hunter, legally trapped and then shot a radio-collared wolf leaving Yellowstone in 2021. He was given a warning by his own wildlife department for not having taken a required trapping course.

In 2021, Gianforte signed a bill with newly relaxed rules for wolf hunting in Montana. Hunters can now trap wolves with neck snares, use bait to lure them, hunt them at night with artificial lights, kill them with crossbows or handguns. Hunters can trap and kill up to 20 wolves each. License sales have no limit. From 2021 to 2023, according to Montana Fish, Wildlife, and Parks, licensed hunters killed more than 750 wolves in the state. Meanwhile, in Idaho in 2021, a bill passed that ruled hunters could use ATVs to run down wolves and use dogs to chase them into spots where they were easier to shoot. In 2021 and 2022, according to the Idaho

Department of Fish and Game, Idaho wolf hunters and trappers killed more than 800 wolves.

One afternoon, I asked Bob Crabtree, founder and chief scientist of the independent organization Yellowstone Ecological Research Center, who has studied wolves in the Northern Rockies for more than 30 years, to help me understand how wolves ideally should be managed. He didn’t hesitate to answer. “By leaving them alone.” Ultimately, wolves manage themselves. “That’s how they evolved,” Crabtree said. “They don’t like their territories to overlap with other packs. If they do overlap, wolves kill each other. If they don’t overlap, they don’t kill each other. They naturally control their own numbers. So, let’s just let nature take its course. Let wolves be wolves.”



LETTING WOLVES BE WOLVES was Boyd's view of how they should be managed from the days and nights she tracked the lone wolf in Montana 46 years ago. She hasn't changed her mind. I regaled her with all the criticism of natural recovery that I had collected from talking to others. She wasn't fazed. Wolves navigate gauntlets of people with their own wiles every day, Boyd said. They didn't need to be reintroduced.

"I give the wolves more credit for their resilience and intelligence. I have seen them go to amazing places and survive. We've documented them going everywhere, and we only document a fraction of the actual dispersals. Wolves originally from Montana have recolonized Oregon, Washington, and California."

The wolves didn't need to be rushed back to the Northern Rockies on the enthusiasm of their human advocates. At the slower pace of natural recovery, Boyd said, "the wolves could have had time to adapt and adjust to being more around people. Some of that adjusting means wolves who are too bold will die. Some individuals who have an innate tendency toward mixing with livestock aren't going to make it. But other individuals can learn from ones who were shot and stay away from livestock. I just don't get it. It's not, 'Would they have made it?' They were already making it."

Listening to Boyd, given her life among wolves, I could see a crack of light coming through the wall of arguments for reintroduction. I could picture naturally recovered wolves in the U.S. going about their daily lives.

And in a way, the wolves that first walked into Montana do live on today. Descendants of the wolves who arrived in Montana on their own and of reintroduced wolves have been breeding for generations. They have merged into one big metapopulation of wolves across Wyoming, Montana, and Idaho. Nevertheless, said Bridgett vonHoldt of Princeton University, an expert in evolutionary genomics, who has studied wolves in the Northern Rockies for more than 15 years, genetics can still connect individual wolves today to the "two original stocks" of wolves from northwestern Montana and those reintroduced.

But the paradox remained. Wolves are being killed in record numbers. Yet they are now flourishing in areas from which they had been wiped out less than a century ago.

When reintroduction began, said environmental lawyer Takacs, "It was very clear that the Fish and Wildlife Service was going to manage wolves for the convenience of people. That has certainly led to an awful lot of slaughter and political agony and controversy. But at the same time, there are now a couple of thousand gray wolves in the West, and that's amazing."

Still, I'm torn. Would wolves, as Boyd said, be better off without reintroduction?

After my very first meeting with Boyd, my brother and I hiked into the Canadian Rockies in Alberta with a wildlife biologist, Dave Huggard. We heard the beeps on Huggard's receiver of a radio-collared female wolf. She was forming a wide circle around us, Huggard said, as she was returning to her den of pups on a hillside, which Huggard had previously spotted.

The female began to howl and was soon answered by the howling of her pups. We stood transfixed in a symphony of howling wolves. Silence returned and we saw the female wolf standing on the embankment of the stream a few hundred yards from us. She stared at us, and we stared at her. In about five seconds, she walked up the scrubby hill to her den, out of our sight.

Our wolf encounter was before U.S. reintroduction began in 1995. Maybe the female wolf and her family would migrate into Montana on their own. Or maybe one of her pup's offspring would be trapped, traumatized, penned, and shipped to America. I hope it wasn't that. So perhaps I do have my answer. ☺

KEVIN BERGER is the editor at large at *Nautilus*.



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5

The Death of Dark Energy

The idea that mysterious stuff speeds up the acceleration of the universe could be a big mistake

BY SABINE HOSSENFELDER

IN 2011, THE NOBEL PRIZE IN PHYSICS was awarded to Saul Perlmutter, Brian Schmidt, and Adam Riess for discovering that the expansion of the universe was accelerating. They came to this conclusion by observing faraway exploding stars. These distant supernovae showed that the cosmos was getting bigger faster because the farther away the supernovae, the faster it appeared to be moving away from us.

In a recent paper published in *Monthly Notices of the Royal Astronomical Society: Letters*, a group of astrophysicists from the University of Canterbury in New Zealand questioned that Nobel Prize-winning finding.¹

The claim that our universe is not only expanding, but that the expansion is speeding up, has no simple explanation. There is no normal type of energy or matter that can make this happen; it requires a substance with negative pressure, a property that we have never otherwise observed. Indeed, we have difficulties even interpreting what it would mean. Physicists have just called whatever is causing this accelerated expansion “dark energy.”

VADIM SADOVSKI / SHUTTERSTOCK



The simplest type of dark energy is one that is constant both in space and in time. This “cosmological constant” is now one of the key parameters in the standard model of cosmology—the Lambda cold dark matter model—alongside other parameters such as the amount of dark matter, a type of invisible matter that supposedly accumulates around galaxies.

The cosmological constant, if it exists, is thought to make up more than two thirds of the matter-energy budget of the universe. We can already see its effects: The extra expansion makes it harder for galaxies to clump and reduces the number of new stars that form. The cosmological constant would also determine the ultimate fate of our universe, dooming it to an ever-faster acceleration that will cool the universe and everything in it to absolute zero—eternal darkness, and very, very cold.

But the authors of the new paper boldly assert that the standard model with the cosmological constant is just the wrong model for the universe, and that if one uses what they assert is the correct model, we do not need dark energy at all, not even in the form of a cosmological constant.

This is not a bombastic “Einstein was wrong” claim: The authors use the same mathematical framework as astrophysicists commonly do, which is Einstein’s theory of general relativity. This theory has it that all types of energy—including matter, radiation, and pressure—curve space, and the curvature in return influences how the energy-types move. The authors of the new paper, led by Antonia Seifert, don’t question this. They question instead how we use Einstein’s math.

Because there is a lot of matter in the universe, in practice we can’t do calculations with the exact distribution of stars and

A few galaxies over, time might run at a slower pace.

galaxies that we observe. There are just too many! Therefore, we make a big simplification. We say that if we average over sufficiently large distances, then stars and galaxies have the same distribution everywhere. It does not matter which part of the universe you find yourself in, it always looks pretty much the same. This idea is called the “cosmological principle,” and if we make use of it, we move from the overarching theory of general relativity to a specific model. And it is this model, the Lambda cold dark matter model, that requires dark energy to accelerate the expansion of the universe.

But strictly speaking, we already know that this model is, of course, wrong. Galaxies and galaxy clusters are not uniformly distributed. Instead, they form a spongy structure, if you can imagine a sponge some dozen billion light-years wide, made of galaxies, and expanding. It has patches with many galaxies in them—such as the one that we find ourselves in—but then there are big voids in between.

This is what the authors of the new paper looked at, a universe that is a patchwork of matter-filled regions like our own and voids. And all these regions interact, pushing and pulling on each other. Now not only do we have an expanding sponge that’s some dozens of billion light-years wide, we have a sponge that doesn’t expand at the same rate everywhere.

The idea itself isn’t new—it’s been around for as long as general relativity itself. The problem is that it’s mathematically difficult to deal with. This is because in general relativity, the patches of different densities and the voids need to be suitably matched together, so that

space itself remains smooth.² And there is no agreement among physicists for how to do this correctly.

Nevertheless, about 15 years ago, David Wiltshire—one of the co-authors of the new paper—put forward a model which does exactly this.³ He called it the “timescape.” This is because, in Einstein’s theory, time runs at different speeds depending on the amount of matter that a region contains. In this timescape model, what we observe in our vicinity, in our own patch, is governed by different laws than what happens on average at larger distances. It is much like how what you observe in your home city may be a poor description for what happens in the world on average. So we might feel that time runs at a normal cadence here in our neighborhood of the universe, but a few galaxy clusters north, time might run at a slower pace.

Wiltshire and his co-authors say that the idea that the universe undergoes an accelerated expansion as a whole is a misinterpretation of what we observe in our vicinity. In the standard cosmological model, these two things—what we observe nearby and what happens in the entire universe—must be identical, because this is how the model works. In Wiltshire’s timescape, this is no longer so. We can then reconcile the supernovae observations with a universe that expands but whose expansion doesn’t accelerate, all without the need for dark energy.

To reach this conclusion, the group of researchers compared how well the Lambda cold dark matter model and the timescape model fit to a catalogue of supernovae observations (which has grown a lot since the Nobel Prize-winning discoveries). In the timescape model, one does not need the cosmological constant,

This is not a bombastic “Einstein was wrong” claim.

but one introduces a new quantity: the ratio of matter-filled patches of the universe to voids. The authors use a Bayesian analysis, which quantifies the probability of a model to be correct, and find that the timescape model actually fits the data better.

This agrees with earlier findings which have built up for some time, that call the cosmological principle which underlies the Lambda cold dark matter model—and with that, the discovery of dark energy—into question. For several decades now, astrophysicists have found structures in the universe that are too large to be compatible with the cosmological principle, such as: the “Great Wall,” a collection of galaxies about 1 billion light-years away from us that extends over 1.5 billion light-years; the “huge quasar group” which spans 4 billion light-years; and the recently discovered “Big Ring” that spans 1 billion light-years. According to the Lambda cold dark matter model, these large structures should not exist.⁴ Yet they do.

While I am sympathetic to the idea of the timescape universe and think it has a lot of potential, I also think it is too early to declare the end of dark energy. Analyses like the one in the new paper, depend a lot on their assumptions (priors) and the data used, and I would not be surprised if another group soon claims that Lambda cold dark matter is superior after all. Questions like this one take time to settle.

Think, for example, of the long-standing argument about whether dark matter or modified gravity is a better fit to astronomical observations. Depending on which assumptions you make (the priors you choose), the same data is either evidence for modified gravity, or against it, or requires Newton’s constant to vary.

I see another problem with the timescape model. Even though the equations that Seifert, Wiltshire, and their colleagues used in the new paper have the same number of parameters as the Lambda cold dark matter model—meaning they have equally many numbers that

need to be specified for the model to be predictive—their full model is significantly more complicated than the standard one. And, at least to me, it has remained unclear how to do calculations in their model. My own cognitive shortcomings say nothing about the validity of the model, of course, but the fact that using the model would require a steep learning curve makes me expect that its adoption in the astro-community will be slow.

As they say, all models are wrong, but some are useful, and whatever your misgivings about dark energy, it certainly has proved to be useful for explaining many observations, such as the features of the cosmic microwave background and the growth of galactic structures. It will take a lot more than one paper to convince astrophysicists that dark energy should be declared dead. ☺

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Scent Makes a Place

How the desert taught me to smell

BY KATY KELLEHER





IN THE LATE SPRING, the desert smells like chocolate. It's fleeting, and it isn't everywhere in New Mexico, but sometimes, walking in the scrubland, it suddenly hits: a sweetness shimmering through the air. At first, I didn't know how to read this olfactory information, but now I can look for the source: yellow-petaled flowers with dark centers—chocolate daisies—blooming in the sun.

The American Southwest smells unlike anywhere I've lived before. It's better than the woods of Maine; it's far more fragrant. I didn't expect that when I moved here. I'm a perfume collector, so I had smelled the desert through art before I smelled it in person. Through my experience sampling "Mojave Ghost," "Arizona," and "Desert Eden"—perfumes designed to evoke cactus flowers and conifers—I thought the mesas would smell dusty and musky, with a little green cypress thrown in. I was wrong.

Here, the plants hold their essences close to the stem out of necessity, only letting their oils free when it's safe to do so, when they're ready to be fertile. Here, the sand bakes under the sun and the fragile soil releases its secrets with each step. Here, even my dog's urine is more potent, more fragrant on the wind, a louder yellow than I ever witnessed during our walks in Maine, blending uneasily with the gray rabbitbrush. It's wetter and stranger than I ever anticipated—complex, elusive, fecund.

After a year in Santa Fe, I've finally started to scratch the surface of knowing this landscape. But the learning is slow and requires all my senses, including the one most often forgotten, what Hellen Keller called the "fallen angel" of the body. Unable to see or hear, smell became her primary way of reading the wider world; she lamented how that "most important" sense had been "neglected and disparaged" by the general populace, though she found it hard to communicate this knowledge to others. "It is difficult

to put into words the thing itself," she wrote. "There seems to be no adequate vocabulary of smells, and I must fall back on approximate phrase and metaphor."

Perhaps due to our trouble translating scents into language, it was once common wisdom that human noses were weak, shoddy things compared to our animal friends. Time and research has challenged that paradigm. Although we don't have the smart wet noses of dogs or the large nasal chambers of reptiles, humans can discriminate between an estimated 1 trillion different odors; the myth of our poor olfaction is rooted in the Victorian distaste for all things scented and the Puritanical eschewing of all things bodily. In other eras people assumed that odd smells were evidence of impending illness, ghostly presences, or moral failings, rather than taking them for what they were.

We've also numbed our noses into oblivion, dulling our most primal sense with the overwhelming presence of synthetic musks and so-called "clean" compounds, used to scent everything from candies to detergents. So when I go outside and try to smell the air, identify the plant, find the source of aromatic joy, I'm engaging in an uphill battle, fighting both my culture and my exhausted, chemical-addled olfactory bulbs.

Yet it's a wildly worthwhile thing, to immerse oneself in a landscape, and savoring the scents of place is a crucial element of this process. "Olfactory scientists have considered smell to be largely the purview of the unconscious, but by putting a smell into words we bring

Sniffing, searching, naming: These actions enable us to more thoughtfully engage with our environment.

it into consciousness,” explains Asifa Majid, a cognitive scientist at the University of Oxford who studies both language and olfaction. Sniffing, searching, naming: These actions enable us to more thoughtfully engage with our environment.

Smell can also ground us in our bodies—my therapist uses scent as a part of our meditative practice—and tie our consciousness to place and time, rather than letting it swirl wildly around the contortions of future-thought. I relish my olfactory abilities because they help me feel embodied, reminding me that I am also a part of the world.

“We are constantly taking a read of our environment and synching,” says artist and theorist Gayil Nalls,* founder of the World Sensorium Conservatory, a repository of “culturally important” botanical scents. Just as we constantly take in information from our eyes and ears, both consciously and unconsciously, we’re also receiving olfactory detail. “It is a big, important way that we understand our environment,” Nalls says.

On New Year’s Eve, 1999, Nalls debuted an “olfactory sculpture” to millions of people in Times Square. This scent was composed from iconic plants from every nation; for America, Nalls chose pine. After speaking

to Nalls, I went for a walk through the scrubby forests at the foot of the Sangre de Cristo Mountains on the Atalaya trails. Almost immediately upon entering the woods, I found myself leaning into trunks, sniffing at the bark of a ponderosa pine.

It was a hot day, and it smelled warm, resinous, homey, and alive. Even in that small patch of forest, each tree—piñons and junipers, bristlecone pines, and cypress—smelled distinctive, each plant had its own olfactory fingerprint, and together they created a complex and resonant symphony of a very particular smellscape. The more I sniffed at bark, the more confused I became. What did pine even smell like, anyway? It was only when I stepped back that the forest came into view. Iconic and piney, certainly, but also so much more.

I could list each note that sung with the pine, laying it out beat by beat. That’s how perfume companies do it: They give you the top, middle, and base notes. Sometimes this information is provided right on the packaging, though one still must sniff the nozzle to understand how they all come together. Language can only offer a loose approximation of a perfume, and a perfume can only offer a loose approximation of a natural smellscape.

**Gayil Nalls is married to John Steele, who is the publisher of Nautilus.*

DESERT CANDY Blooming chocolate daisies, more lyrically known as lyreleaf greeneyes, are part of Southwestern smellscape from spring to fall.





“We underestimate the human sense of smell, but we notice it a great deal when it is gone.”

THE AIRY SCENT THAT FOLLOWS rain is known as petrichor, and there are many forms. The petrichor in Singapore, for example, will be quite different from that of Reykjavik. The desert smells most intensely after a sudden summer downpour, when the plants release their oils, when the soil opens its pores to the sky. Nevertheless, perfumers have identified a common essence to petrichor: the chemical compound geosmin. It takes its name from the Greek words for “earth” and “smell.” In small amounts—and we are able to detect *very* small amounts of geosmin, down to 10 parts per trillion, akin to a stick of incense diffused through the entire Empire State Building—it smells familiar and musty, a little minerally, a little dirty, but in a nice way. In larger doses, it can come across mildewy and rank, like dirty laundry left in a damp basement. In nature, geosmin is produced by certain species of blue-green algae that live within soil, and is part of the fragrance bouquet that gets released into the air before, during, and after the high desert gets hit by rain.

For perfumers, the discovery and naming of geosmin in the 1960s was a boon, although it did take several more years to perfect the lab-synthesized version of the compound. It can be used in perfumery to add a muddy, petrichor scent to the bouquet. Since most fragrance houses don’t release a list of their chemical compounds, it’s not always easy to know when you’re smelling geosmin, but if you’re looking for a desert-inspired smellscape, there’s a good chance that synthetic petrichor will be part of the mix.

Indie perfume house Solstice Scents makes a botanical, woody scent called “Desert Thunderstorm,” which features sage, pinon resin, sweetgrass, creosote brush, sand, and petrichor among its notes. Another atmospheric perfume, “Two cups of tea, a summer monsoon, and me and you” by Death and Floral, also relies heavily on petrichor to ground it in place. Both can veer mildewy if worn too heavily. That’s the risk of geosmin thanks to our remarkable sensitivity to this compound.

A smellscape is more than the list of chemicals found in a location. It's a poetic map of the world.

But there are other ways to get a rainy desert scent, according to Cebastien Rose and Robin Moore, perfumers at the Albuquerque-based company Drylands Wilds. Unlike most perfumers, they don't use synthetic odor molecules; their ingredients are derived from locally foraged plants, and through their work, they've become experts in the various scentscapes of New Mexico. Including greasewood, which is often considered a pest plant, a garbage scrub that needs getting rid of but is also responsible for an earthy, fresh Southwestern scent that wafts from its leaves. "Right before it rains," explains Rose, "it opens all its stomata." These "tiny mouths" are how the plant breathes, and as the rain begins to fall, the leaves release aromatic organic compounds called cresols, which smell a bit like coal tar and—thanks in part to their association with rainfall—a lot like a drenched desert.

"We're obsessed with trying to capture that exact experience of being out here, walking the hills, smelling the piñon resin when it gets hot, smelling the ponderosa bark that wafts the air with vanilla," Rose says. But it's not enough to simply extract oils from the bark. It's even difficult to capture a single tree in perfume form, says Rose. Plus, that wouldn't reflect the experience of walking under the "giant, orange-barked trees. You wouldn't get the oak moss, the soil, the place." That, explains Rose, is where the "art of perfumery" comes in. The Dryland Wilds ponderosa perfume has yellow nut-sedge, sweet clover, piñon, oakmoss, fir, and ponderosa. It contains extracts that mimic the dirt, resulting in a liquid that smells like a tree, yes, but is also intended to smell like a moment—a dry summer afternoon on the

Atalaya trails, for instance. "We've had people cry after smelling it," adds Moore. "One woman had lived in a ponderosa tree trying to protect old growth forest for a year, and for her, that hit was instantaneous."

To me, this perfume feels more like an artistic interpretation, a translation of experience, as emotionally resonant as a poem or a song. "It's not just about creating a nice-smelling thing," Moore had said. "It's about trying to connect and reconnect to these spaces. To connect and inspire a sense of stewardship." It's a lot to ask from a splash from a \$32 perfume bottle, but perhaps scent could inspire action. It's what Nalls is hoping for, too. And doesn't every artist want, at least on some level, for their work to change the world?

PERFUMERY IS AN ANCIENT ART. It's also a lucrative product. According to Stuart Firestein, a neuroscientist at Columbia University who studies olfaction, most of the funding that goes into research about the nose comes from the fragrance industry; compared to vision, which is well-studied and well-funded, we know relatively little about both the physiology and psychology of perceiving scent.

That is beginning to change as more scientists look to the olfactory system for insight into the brain. This is what drew Firestein to the field. "For many years, we have used the vision system as a way to understand the way the brain works. And we did learn a lot about brain function from the retina. But little by little, the visual system has become less interesting," he explains. Unlike light, which can ultimately be understood as variations along what Firestein calls the "single

dimension” of wavelength, scents can’t be broken down into a neat spectrum. The olfactory system is stranger and more unwieldy than sight, harder to grasp yet arguably more representative of how the brain performs its essential functions, from retrieving memory to processing emotion.

Smell, as a sense, is dependent on so many variables—it can be affected by our previous experience, our current context, and our emotional or mental state. Something may smell “good” in one scenario and disgusting in another. How we judge a smell can be changed by the sounds we’re hearing, the temperature that surrounds us, the food we’re tasting, the colors we’re seeing. It’s a sense that shifts and slips, sometimes in predictable ways but sometimes in totally unexpected directions. Much like the brain as a whole.

To lose your sense of smell, Majid points out, is to experience a disruption in perception that can have massive emotional and psychological impacts. “The human sense of smell is strongly linked to well-being, so much so that when people lose their sense of smell they report it deeply impacts their quality of life, and it can even be linked to depression,” she says. “It’s a sense we take for granted, as much as we take breathing for granted.” Firestein agrees. “In general, we underestimate the human sense of smell,” he says. “But we notice it a great deal when it is gone. Suddenly, people complain quite vividly about their sense of smell. They can know they are home, see all their stuff, but they don’t *feel* like they are at home. It’s invasion of the body snatchers.”

I’ve always been keenly aware of the scent of my home and the scents of my body, but over the past year, since moving to New Mexico, my relationship to outdoor scents has dramatically changed. At first, I was picking out individual scents and identifying their sources, a one-by-one exploration of the landscape that gave me a good deal of surface level knowledge about the desert’s flora and fauna. As I began to know the strongest smells—greasewood leaves, ponderosa pines, chocolate daisies—I also began to recognize the interplay between them, much in the same way that I recognize the distinct smellscape of my bedroom. It now makes sense to me why perfumers refer to scents as “notes.” Emotionally complex, effective, and evocative art is typically made with more than one note; it’s

the combination that elevates something from music to song, oil to perfume.

Similarly, a smellscape is more than the list of chemicals found in a location. It’s a poetic map of the world, fed to us through our oldest sense. The smells of the desert are more than just sweet, dusty, dry, or sharp. Each smell is a distinct sensation, but together they are more than that. Smellsapes are part of place-making, the process by which a site becomes imbued with meaning and metaphor; a *place* is more than just the physical location. Places have history, lore, memory, and emotion all infused into them, and encounters we have with a place are participatory.

It’s of course impossible to remake the smellscape of the desert in a single piece of art. The place is continually changing based on the weather, the time of year, the exact location, and just as importantly, my mindset. The most we can ask from a perfume is that it evokes that sense of the place, opening doors in memory that we can choose to walk through. And like landscape painters, who often alter colors and dramatize scenery for effect, perfumers are free to play with their ingredients to create something that is both more and less than the real experience. They can create an atmosphere that speaks to our experience of nature without reproducing it note-by-exact-note.

Smelling a landscape, and knowing, on a deep level, the scent of a place—these actions bring us more into the world. And when a site becomes a place, we’re better equipped to celebrate and protect it.

I plan to leave this landscape at some point, returning to my family back east, my little house in the Maine woods. I will spend many cold New England days aching for the bright sensations of New Mexico. I’ll feel place-sick but perhaps will find solace in a pathway back, in my mind, cleared by just the right desert perfume. This scent of place weaving a web of connection across an entire continent. ☺

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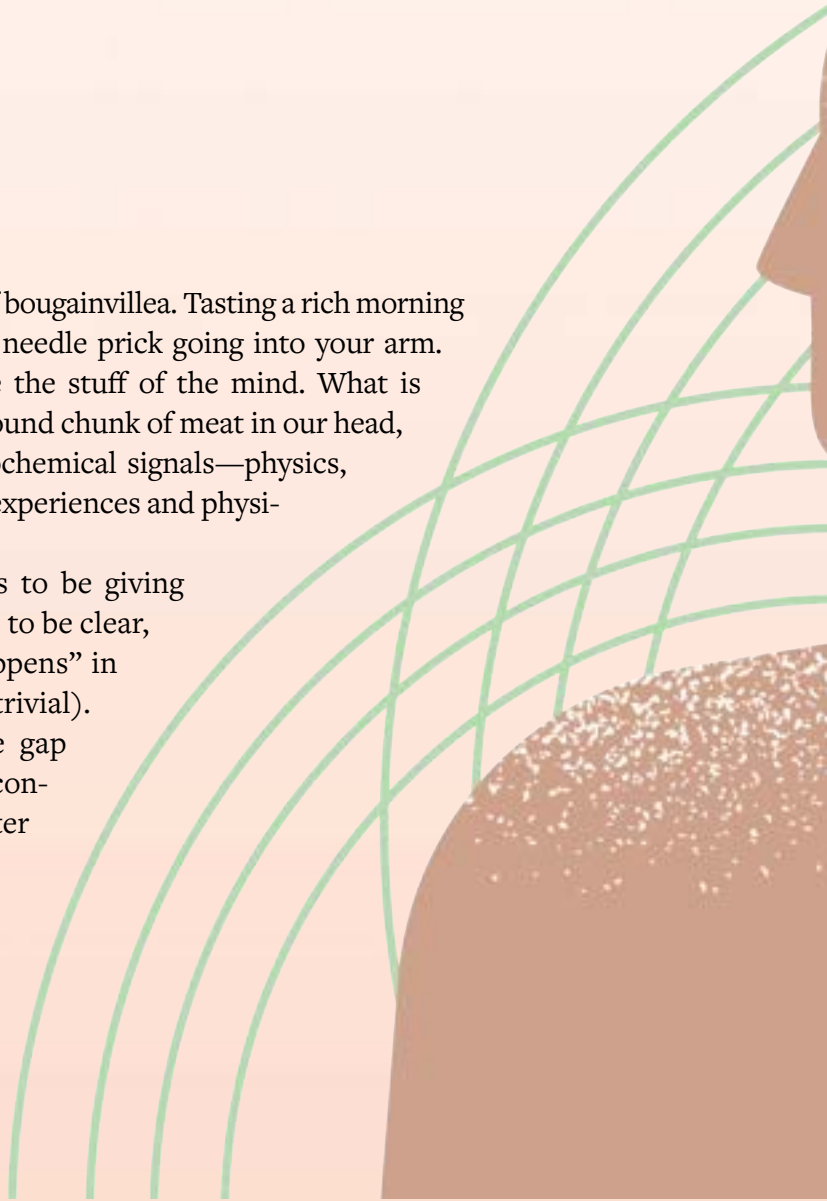
Consciousness Has a Psychology Problem

The biases that shape our understanding of the mind

BY IRIS BERENT

SEEING THE STRIKING MAGENTA of bougainvillea. Tasting a rich morning latte. Feeling the sharp pain of a needle prick going into your arm. These subjective experiences are the stuff of the mind. What is “doing the experiencing,” the 3-pound chunk of meat in our head, is a tangible object that works on electrochemical signals—physics, essentially. How do the two—our mental experiences and physical brains—interact?

The puzzle of consciousness seems to be giving science a run for its money. The problem, to be clear, isn't merely to pinpoint “where it all happens” in the brain (although this, too, is far from trivial). The real mystery is how to bridge the gap between the mental, first-person stuff of consciousness and the physical lump of matter inside the cranium.





Human cognition, as we know it, is laced with biases.

Some think the gap is unbreachable. The philosopher David Chalmers, for instance, has argued that consciousness is something special and distinct from the physical world. If so, it may never be possible to explain consciousness in terms of physical brain processes. No matter how deeply scientists understand the brain, for Chalmers, this would never explain how our neurons produce consciousness. Why should a hunk of flesh, teeming with chemical signals and electrical charges, experience a point of view? There seems to be no conceivable reason why meaty matter would have this light of subjectivity “on the inside.” Consciousness, then, is a “hard problem”—as Chalmers has labeled it—indeed.

The possibility that consciousness itself isn’t anything physical raises burning questions about whether, for example, an AI can fall in love with its programmer. And since consciousness is a natural phenomenon, much like gravity or genes, these questions carry huge implications. Science explains the natural world by physical principles only. So if it turns out that one natural phenomenon transcends the laws of physics, then it is not only the science of consciousness that is in trouble—our entire understanding of the natural world would require serious revision.

But before we run off too fast and far, let us pause, take a breath, and reconsider. The mind is hard to explain in physical terms—this much is obvious. *Why* it is hard, however, is far from evident. In fact, this question is open to two competing explanations. The first explanation puts the blame on what consciousness is—that it is not physical, as Chalmers claims. Alternatively, this impression (that consciousness isn’t physical) could arise from within, as a result of human bias—a psychological delusion.

PSYCHOLOGICAL BIASES ARE RELEVANT because philosophers and scientists heavily rely on their intuitions as they try to explain what consciousness is. Is it special—can it reveal more about the world than what I can infer from my reason alone? Does my conscious experience seem physical? Can a person lack conscious experience, even if their body looks and works just like mine?

In these mini-thought experiments, intuitions are data. Since consciousness generates intuitions, intuitions *can* speak to what consciousness is, at least in principle. The problem is that the “psychology of psychology” is a tricky business.

Human cognition, as we know, is laced with biases—we can readily recognize these distortions in visual illusions, auditory hallucinations, and logical fallacies. So, if our perception of the external world is distorted, why assume our internal perception is truthful? In fact, people are demonstrably plagued by multiple biases that cloud their reasoning about how their own psyche works.

Intuitive dualism is one such psychological bias. It suggests to us that the mind is ethereal, distinct from the body. My research suggests that intuitive dualism arises in humans naturally and spontaneously—it emerges from the two innate systems: One guides our understanding of the physical properties of objects; another helps us “read” the minds of others. So it is not the product of rationally analyzing what exists. It is a psychological delusion that arises from within the human mind itself.

However, intuitive dualism has been shown to give rise to various prejudices, ranging from the denial of human nature to our misguided fascination with neuroscience and the tendency to stigmatize people with psychiatric disorders. Our consciousness intuitions could arise from the same source as these biases.

So, if consciousness appears somehow distinct from physical reality, then this conclusion could well arise not from what consciousness really *is*, but rather from what our psyche is telling us, courtesy of intuitive dualism.

How can we tell, then, whether or not our intuitions (that consciousness is not physical) reflect what consciousness really is? It looks like we are at a stalemate. And that’s a problem for the “hard problem.”

RECENT RESEARCH HELPS US move forward. To see how, suppose you inspect yourself in the mirror: Your face has an unhealthy greenish hue. Before rushing to the ER, you step outside and reexamine your image in natural light. The greenish appearance changes, you are all clear; the strange color was likely an artifact of the lighting. Shifting intuitions are diagnostic—they can help us identify our own biases.

The same logic can help us sift consciousness fact from fiction. If our intuitions about consciousness faithfully reflect what consciousness *is*, and if the nature of consciousness is invariant—meaning it doesn’t change from being physical to non-physical—then our intuitions about the nature of consciousness should also not change. In other words, they should not vary by context. But if consciousness intuitions shift, such that, in some situations, consciousness seems ethereal, and in others, it seems physical, then it’s likely something about our psyche that explains these intuitions, not consciousness itself.

When such shifts are detected, it’s a telltale sign of a psychological delusion, just like the shifts of your greenish complexion above. And if we could further explain how these shifts arise from within—by spelling out their psychological causes, then our confidence in this psychological explanation would increase further. Such shifts in consciousness intuitions, then, suggest that our intuitions can’t be trusted to reveal reliable information about the nature of our minds. This is precisely what psychological experiments probing our intuitions about consciousness show.

Sometimes this involves asking people to consider the idea of a philosophical zombie. Philosophical zombies are hypothetical creatures that lack consciousness yet everything else physical about them—including their biology and brain chemistry—matches humans perfectly. The idea is that if someone believes consciousness is



distinct from physical matter, then that person should think philosophical zombies could, in theory, exist. And if philosophical zombies are conceivable, then perhaps the possession of an intact human body does not guarantee consciousness. Consciousness, so the argument goes, is thus distinct from the physical.

When philosophers are surveyed, most respond that, indeed, zombies are conceivable. But what about most people—do they, too, share these intuitions?

In a 2021 paper published in the journal *Cognition*, researchers Eugen Fischer and Justin Sytsma had participants think about whether the idea of a “philosophical zombie” made sense. To find out, they asked people to rate whether philosophical zombies would be capable of having conscious experiences, feelings, and emotions. Responses hovered around the “neutral” midpoint of the seven-point rating scale (four, “neither agree nor disagree”). Few participants, to be sure, outright denied that zombies are conscious, and fewer yet denied that zombies are conscious while affirming that they have a functional, humanlike body (as the instructions to the experiment suggested). This last result could either indicate that most people cannot fully conceive of philosophical zombies or that participants are simply reluctant to respond “no” (e.g., *No, zombies aren’t conscious!*).

Indeed, in a 2022 study published in the *Proceedings of the National Academy of Sciences*, my colleagues and I showed that when participants are forced to give a binary response (instead of a seven-point rating scale that allows them to “sit on the fence”), participants state that a perfect replica of a person’s body will *not* maintain their mental states—thoughts and beliefs. Insofar as consciousness is a mental state, this would imply that zombies do not seem possible.

Either way, participants in Fischer and Sytsma’s study certainly did not ascribe much conscious experience to zombies, even though the problem framing clearly established that these creatures have a human body. Consciousness, for them, seems to be at least partly distinct from the physical.

So far, then, it looks like most people intuit that consciousness is ethereal; at least, that is what they say about philosophical zombies. It is therefore tempting to conclude that what’s true for zombies could hold for the many other scenarios that philosophers have used

to probe our consciousness intuitions. After all, if we assume that these scenarios shed light on what consciousness *is*—and for what we know, consciousness does not change—then what’s true in one case ought to be true in all.

The physicality case, it would seem, is closed; our intuitions tell us that consciousness isn’t physical. So strong is this tacit conviction that, to my knowledge, no one has bothered to check whether this is really the case. But it turns out that when most people are asked to consider a second famous case—the problem of Mary in the black and white room—people tend to view consciousness as squarely physical.

MARY, THE THOUGHT EXPERIMENT GOES, is a neuroscientist who is an expert on color vision. Mary herself, however, has never seen color, as she lives in a black and white room. Now, suppose that Mary steps out of that room and sees a red rose for the first time. How significant is that conscious experience? Will it register or “show up” in Mary’s brain?

A series of experiments from my lab at Northeastern University presented participants with several versions of Mary’s case (a total of 180 people across four different experiments). Their task was to rate not only the significance of that new conscious experience (specifically, “How transformative is Mary’s experience seeing the color red? How much has her grasp of ‘red’ changed by seeing the red rose?”) but also its embodiment—whether it is likely to “show up” in Mary’s brain.

The philosophical literature leads us to expect that Mary’s new conscious experience is significant—it has utterly transformed her grasp of color, and participants agreed. In fact, their ratings in response to the “transformative” question (above) were significantly above the midpoint of the seven-point rating scale, so clearly, participants did view this experience as quite significant. But when asked whether Mary’s conscious experience will “show up” in a brain scan (i.e., in Mary’s physical body), they said it will!

Participants further believed that Mary’s first conscious experience of red is more likely to manifest in the brain scan than all of her “abstract” knowledge about color vision. In fact, the more likely participants were to state the “red” experience would “show up” in the brain, the more transformative it seemed. Thus, not

Why should a hunk of flesh experience a point of view?

only did participants consider Mary's conscious experience as squarely embodied, but embodiment was also linked to the significance of this experience.

In another experiment (from the same study), participants were asked to assume that Mary's first encounter with the red rose happens in one of two conditions (presented to Mary as part of a carefully controlled experiment). One condition has Mary looking at the red rose in full view for several seconds; when asked to report her experience, Mary confirms seeing it. In a second condition, the red rose is presented for just a fraction of a second. When asked about what she saw, Mary reports seeing nothing. Despite this, participants are told, seeing the red rose for just a fraction of a second is likely to have registered in Mary's brain since research has shown that after such subliminal presentations, the word "rose" comes to mind more readily.

The two conditions (the subliminal and conscious), then, are identical except that one engenders consciousness and the other doesn't. By comparing them,

we can directly examine intuitions about consciousness (as opposed to "seeing color"). If responses to the two conditions differ, then, this difference will shed light on how consciousness is perceived—whether it is transformative and whether it is embodied in Mary's brain.

Results showed that participants considered Mary's conscious experience (in the first condition) as more transformative than her subliminal experience (in the second condition); this is only expected from the philosophical analysis. But, contrary to what might be expected given the "hard problem," participants also considered the conscious experience to be *more* likely to "show up" in Mary's brain compared to the subliminal experience. And once again, "transformative" ratings were *positively* linked with the brain registering the experience, such that the stronger the intuitions that Mary's conscious experience registered in her brain, the more transformative it seemed.

These outcomes are striking for two reasons. First, the results show that, when people consider Mary's



Consciousness does not change—what’s true in one case ought to be true in all.

case, consciousness seems to them squarely physical. This flies in the face of the common wisdom that consciousness seems not physical. Second, when compared with the zombie’s case, it appears that these psychological intuitions shift.

In the zombie’s case, consciousness seems ethereal; in Mary’s case, it seems physical. And if different thought experiments can produce such a radical shift in intuitions about the nature of consciousness, then our intuitions about subjective experience cannot possibly be trusted to reflect what consciousness really is like. This means our intuitions about consciousness likely emerge from within—from psychological biases.

OUR INTUITIONS ABOUT CONSCIOUSNESS are shaped by two competing psychological biases: intuitive dualism and essentialism.

A large body of literature suggests that people—adults and young children, across various societies and cultures—consider the mind distinct from the body. For

intuitive dualists, philosophical zombies don’t seem so strange. Since dualists see the mind as ethereal, distinct from the body, they can readily imagine a creature that shares only our body, but not the inner light of conscious experience. From the outside, the creature seems just like any real person; but on the inside, there’s nobody home. They’re as conscious as a rock.

Had our intuitions about consciousness stemmed *only* from intuitive dualism, then consciousness should have always seemed ethereal, just as the case of zombies suggests. But psychological biases, such as intuitive dualism, do not operate in a vacuum; they often interact with conflicting biases. And when these interactions occur, a bias that was previously silent can suddenly become dominant. Critically, the “push and pull” dynamics between them can also be shaped by context. When context shifts—when people consider different thought experiments about consciousness—the role of dualism may be weakened. Consequently, intuitions about the link between consciousness and the brain shift, too.

Mary's case invokes just that shift in intuitions. What's different about Mary's case (relative to zombies) is that it invites us to evaluate a *change* to Mary herself (her new experience with color), and as a result, we now focus on her body, more than her mind. This attenuates the effect of intuitive dualism and brings a second competing constraint into the forefront—intuitive essentialism.

Essentialism is the intuitive belief that living things are what they are because they possess some innate, immutable essence that lies within their bodies. Research has shown that when people evaluate a change to a protagonist, they assess whether the change pertains to the protagonist's essence. And since that essence seems to lie within the body, it is the body that determines the significance of that change.

For example, young children believe that a change to a dog's insides (like removing its blood and bones) amounts to changing the kind of thing that it is, whereas external changes (like removing its fur) will not, presumably because it is within the "insides" that the animal's hidden essence lies.

Like the dog example, Mary's case also features a change. So for an intuitive essentialist, Mary's newly gained consciousness of the redness of the color red ought to be significant or transformative only if this change pertains to her bodily essence. It follows that, to engender a significant change, a new conscious experience *must* affect Mary's body. Seeing color fits the bill, because "seeing" intuitively feels like an embodied affair that involves the eyes. Accordingly, participants viewed Mary's conscious experience as "transformative."

Moreover, seeing color is significant precisely because intuitively, this experience seems physically embodied. The results also showed that the more "embodied" Mary's experience seemed, the more transformative it was. This link between "embodiment" and "transformativeness" is exactly what intuitive essentialism predicts.

Together, intuitive dualism and essentialism can both capture our conscious intuitions. The crucial point, however, isn't just *why* and *how* consciousness intuitions shift. Rather, it is the fact a shift *occurs* that is critical. And since it does, you know you could be in trouble—your intuitions could well arise from your internal psychological biases. So, resist the temptation and do not blindly follow their delusional voice. Don't trust your consciousness to tell you what consciousness really is. ☺

IRIS BERENT is a professor of psychology at Northeastern University and the author of *The Blind Storyteller: How We Reason About Human Nature*.



Balloon-Borne Telescopes Take Off

Stratospheric balloons are giving astronomers sharper views of the universe

BY ADAM MANN





IN A NEARLY CLOUDLESS DAY in 2023, a helium balloon the size of a United States football stadium lifted off from an airport in New Zealand. It quickly rose 110,000 feet above the Earth, ascending into the stratosphere, a layer of the atmosphere that is out of reach of clouds, rain, and storms. Beneath the balloon, attached by a pair of 300-foot steel cables, dangled an enormous piece of astronomical equipment: a telescope powered by solar panels and batteries. The entire payload weighed about as much as a Volkswagen Beetle.

Over the next 45 nights, the balloon and its high-tech cargo soared over Antarctica, its flight path guided only by the wind.

The flight was essentially a test run. The first order of business was to see if the new technology used to build the balloon would work. Overnight, other scientific balloons often rise and fall by as much as 45,000 feet as their helium expands and contracts with changes in air temperature, but a novel design, called super-pressure heavy-lift, allowed this balloon to maintain a tight, specific altitude. The second part of its mission: to collect detailed pictures of the cosmos with the telescope, known as SuperBIT. Soon, dazzling impressions of distant galaxy clusters crashing together—their stars, dust, and gas spreading outward—winged their way back to Earth. The pictures were pin sharp.

That's because the view is different from the stratosphere than it is from a mountain top, where most land-based telescopes are based. Even at the pinnacle of the tallest mountain on Earth, the atmosphere contains water vapor and other substances that absorb certain wavelengths of light and blur images. But where astronomical balloons do their work, the air is thin and dry, allowing for clear views of the universe beyond.

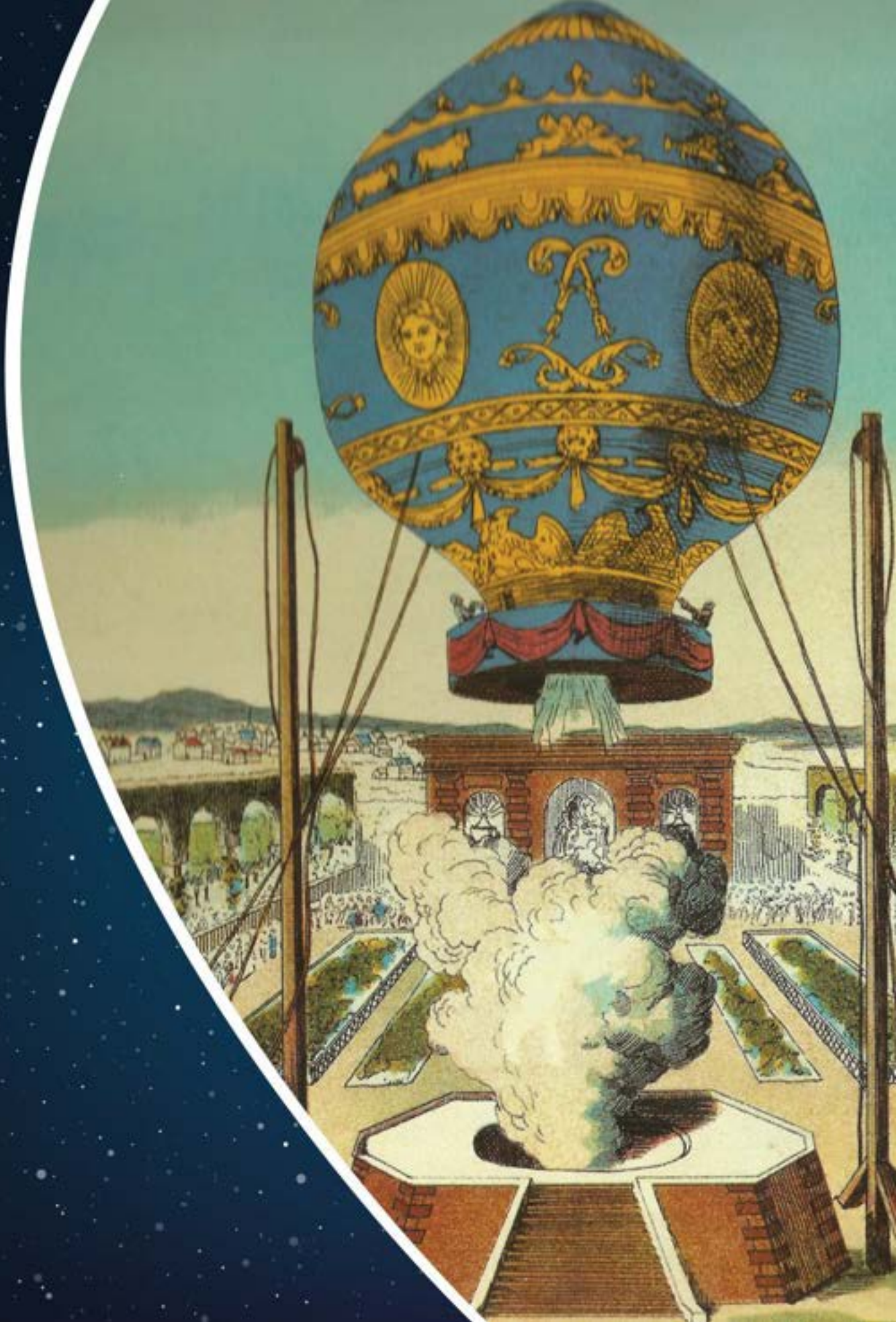
Space can offer a clear view, too, but sending a telescope up with an astronomical balloon costs a tiny fraction of what it would cost to strap it to a rocket. These telescopes tend to run between \$5 and \$10 million, compared to the many billions of dollars that the Hubble Space Telescope has cost over its lifetime. And unlike an orbital mission, failure is an option. If the telescope malfunctions, it can often be fixed and relaunched. Shorter mission timelines—days or months rather than years—mean parts can be regularly serviced and upgraded. It's a lot better for the environment, too: Balloons don't expel pollutants or leave debris in space.

Balloons don't expel pollutants or leave debris in space.

Advances in technology keep pushing NASA's balloons to greater heights. In September 2024, a test flight out of Sweden reached a record 160,000 feet. "Each time we break another barrier, we get above enough atmospheric particles that the clarity just gets better and better," says Sarah Roth, chief technologist for NASA's Balloon Program Office at the Wallops Flight Facility in Virginia. Balloon-borne instruments keep growing in size and sophistication, too. More and more, researchers are dreaming up ambitious new ways to explore celestial objects and cosmic forces with balloons.

IN THE FALL OF 1783, a sheep, a duck, and a rooster were placed into a wicker basket attached to a hot air balloon in Versailles, France, while a crowd of onlookers, including King Louis XVI, stood by and watched. The creatures soon ascended to over 1,500 feet, but less than 10 minutes after takeoff, the balloon crash-landed in nearby Vaucresson Forest. A rip in the fabric had caused the balloon to deflate. (A doctor examined the animals and found them to be alive and in good health.) It was the first time a balloon had carried passengers into the sky. Modern balloon flight had been born.

Scientists themselves were soon climbing aboard. From the beginning, they had understood that lofting into the atmosphere offered new opportunities to take measurements of the world. The American physician John Jeffries sampled air at different elevations during a 1784 flight over London. Two decades later, a French chemist named Joseph Louis Gay-Lussac ascended to 13,000 feet in a balloon to study how the Earth's electromagnetic field varied at different locations above the surface. As balloons floated ever higher, researchers realized that at certain altitudes, they had difficulty breathing, could no longer move their limbs or speak, and, eventually, would pass out from oxygen deprivation. So scientists began sending equipment in their stead.



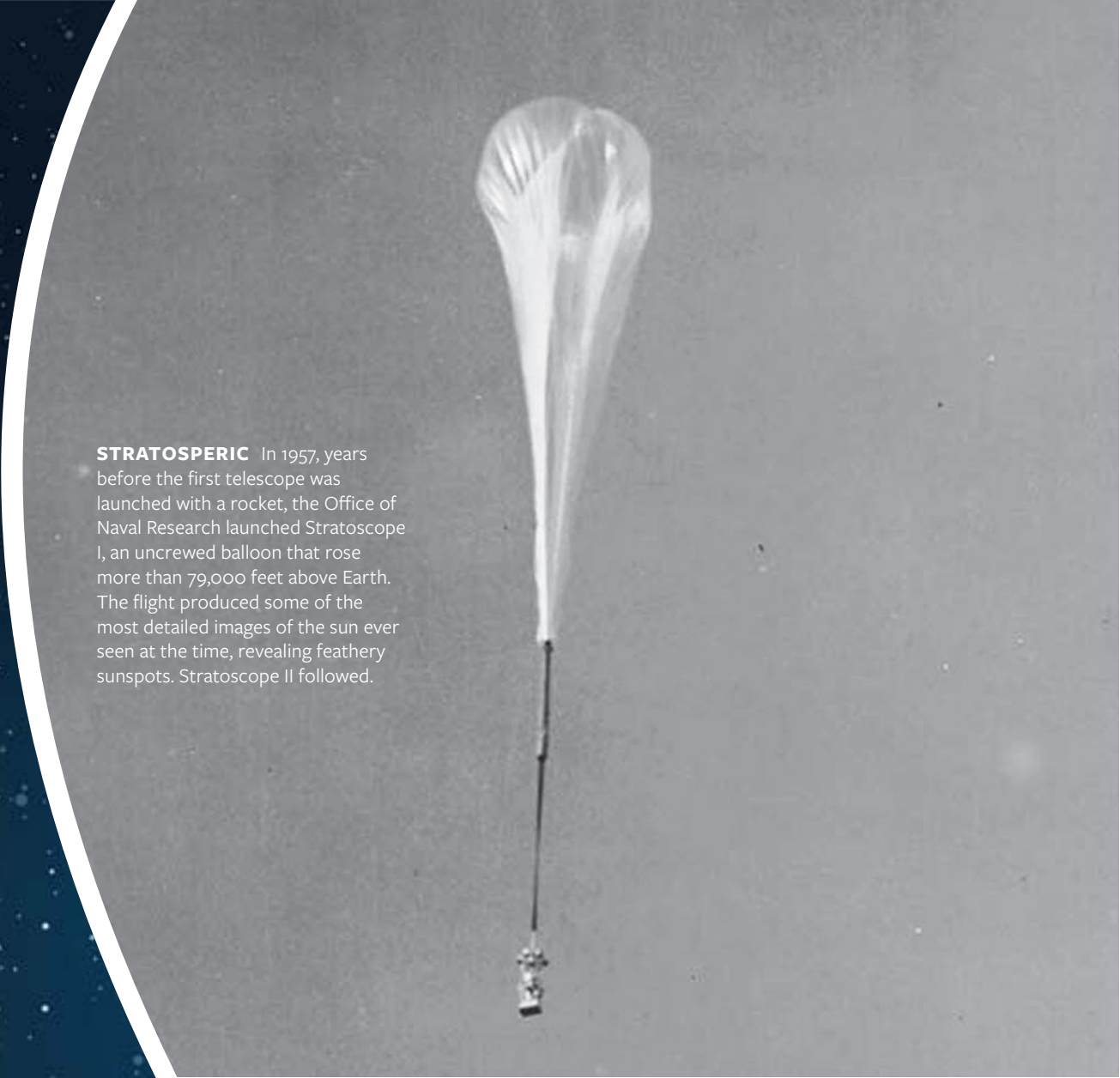


In 1783, a sheep, a duck, and a rooster were placed into a wicker basket attached to a hot air balloon in Versailles.

But it wasn't until 1957—years before the first space telescope—that astronomers launched the first telescope on a balloon: The uncrewed flight reached more than 79,000 feet above the Earth and produced what were, at the time, some of the sharpest and most detailed pictures taken of the sun, showing roiling convection cells on its surface and dark, feathery sunspots. The telescope's successor, the Stratoscope II, collected infrared light from Mars and peered at interstellar dust, finding much less water than previously suspected in both cases.

WHILE A BALLOON MISSION is both cheaper and easier than sending an observatory into space, it's still a complex undertaking. Today's balloons are themselves technological marvels, composed of 20-micrometer-thick polyethylene film, roughly the same thickness as plastic wrap. Sheets of this material are heat-sealed together to create a spherical structure with more than 35 million cubic feet in volume, which is then filled with helium at a specific pressure to loft it to the desired height above the Earth's surface. Such ultra-long-distance super-pressure balloons, as they're known, can carry up to 8,000 pounds and circle the stratosphere for almost two months.

HOT AIR The Montgolfier brothers designed some of the earliest scientific balloons, including this one, which was powered by hot air and carried human passengers. Here it is pictured in Paris, on Oct. 19, 1783.



STRATOSPHERIC In 1957, years before the first telescope was launched with a rocket, the Office of Naval Research launched Stratoscope I, an uncrewed balloon that rose more than 79,000 feet above Earth. The flight produced some of the most detailed images of the sun ever seen at the time, revealing feathery sunspots. Stratoscope II followed.

One challenge balloon-borne telescopes face is that the instrument is suspended by a set of steel cables known as the flight ladder. These cables can be hundreds of feet long to minimize how much the balloon itself blocks the telescope's view of the sky, but it means that the instrument dangles beneath it like a pendulum. Though the stratosphere is fairly low on turbulence, even minor disturbances caused by solar activity from above or terrestrial weather patterns from below could easily induce an instrument at the end of such a long cable to sway. Astronomers tend to take long exposure photographs to capture as many faint photons trickling in from the sky as they can, so even a little movement can ruin images.

US NAVY / WIKIMEDIA COMMONS

Balloon telescopes capture astronomical images so detailed they rival those taken by the Hubble.

To resolve this problem, the SuperBIT team placed their telescope inside three nested metal frames fitted with high-precision gyroscopes. When the telescope rotates inside the frames—it can turn 360 degrees—the gyroscopes sense changes to orientation. Reaction wheels, devices that push back against deviations in rotation—also used on satellites and space-based telescopes—correct for these changes. The telescope’s control systems are so precise that you could theoretically use them to stabilize a thread inside the eye of a standard sewing needle.

The result is that SuperBIT can keep its lens focused on a single pinprick in the sky and remain there long enough to capture astronomical images with a level of detail that rivals the Hubble.

ASTRONOMERS ARE NOW USING balloons to help them investigate some of the greatest mysteries of the cosmos—from distant black holes and exoplanets to nearby asteroids and comets.

While SuperBIT is focused on using cosmic collisions to discern the behavior of dark matter, other projects are investigating forces such as gravity. In July 2024, a balloon-borne telescope known as XL-Calibur launched from Kiruna, Sweden. On a five-day trip around the Arctic Circle, it captured X-ray images of a famous black hole known as Cygnus X-1 as well as the pulsating neutron star within the Crab Nebula. Such images can give researchers insight into the presence and distribution of hot plasma or magnetic fields around such massive cosmic objects, which could help us better understand gravity and even whether current theories of gravity need tweaking.

In August 2024, a different group conducted a test flight of a balloon carrying an infrared telescope that aims to build three-dimensional pictures of the atmospheres of “hot Jupiters,” distant exoplanets the same size or larger than Jupiter. A scientific flight led by NASA is expected in the coming years. The agency also hopes to launch another mission within the same time frame that will generate high-resolution maps of gas and dust in the Milky Way in order to study how stars live and die in our galaxy. The telescope for that mission would have an 8-foot-wide mirror, one of the largest of any balloon-borne instrument and larger even than Hubble’s mirror, which would allow it to collect more light and see more distant objects.



Balloon missions have tended to rely on off-the-shelf parts and are mostly run by graduate students, saving money while also helping to train the next generation of scientists. “You could potentially have a fleet of these going around the Earth continuously and not even notice it in the budget of a space mission,” says Richard Massey, a physicist at Durham University in the United Kingdom who helps lead the SuperBIT project. Because the cost and time to develop them is so much lower, researchers can take more risks than they might with a space-based telescope.

With a rocket-launched instrument “almost 90 percent of the design is about forcing it through the atmosphere,” adds Fionagh Thomson of Durham University who also works with the SuperBIT team. This means engineers building a balloon-borne observatory can focus less on their telescope’s ability to survive the rigors of a rocket launch, and more on its scientific capabilities. The relative affordability of balloon missions also increases access to high-quality astronomical data for countries with fewer resources and small institutions like universities, Thomson says, giving more researchers a chance to explore the outer reaches of the universe.

While balloon-borne telescopes will never fully replace ground- and space-based observatories, they’ll likely

NASA/SUPERBIT

NEAR SPACE A view of the tarantula nebula, taken by the SuperBIT telescope on a recent super-pressure balloon flight. The images were captured at a distance of 108,000 feet from the Earth. That's well above the first layer of the planet's atmosphere, where weather occurs, but still a long way from space, which begins at the Kármán line, more than 300,000 feet from Earth.

continue to play an important role in astronomical research. Still, engineers have some kinks to work out before balloon-borne telescopes can reach their full potential.

Data retrieval for SuperBIT didn't go exactly according to the team's initial plans, which involved sending information through SpaceX's Starlink satellites. The instrument ended up acquiring more nightly data than could be handled through Starlink and, on occasion, the satellite connection cut out entirely.

So the team moved to a lower-tech backup plan: dropping two SD cards containing roughly 200 gigabytes from the telescope and having them parachute down to the ground. The SD cards touched down a little over a mile from where they had been predicted to land, in a snowy patch in the Santa Cruz province of Argentina. Cougar prints were found in the snow near one of the cards but there was no evidence of any damage. "We surmise that foam and parachute nylon are intriguing but not tasty," wrote the authors of a paper describing the recovery.

The SuperBIT's test run came to an ignominious end when weather conditions forced operators to terminate its flight just 40 days into a 100-day mission. As it neared its targeted landing site on a remote hill in Argentina, the instrument's parachute failed to disconnect, and it was dragged over nearly 2 miles of rough terrain, leaving a trail of debris and destroying the telescope.

Despite such difficulties, the appeal of balloon-based astronomy remains high. A once elemental idea has grown up, and is helping us understand some of the most elusive forces in the universe—from just 20 miles above ground. 🌀

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Healing on the Edge

Adventure therapy takes on the challenge of helping war-torn families

BY FLORENCE WILLIAMS

PHOTOS BY STEFAN FAULLEND

SUPERHERO

Valentyna S. practices a repel, wearing a Ukrainian flag-style banner featuring the face of her husband, Konstantin.

IT'S NOT EASY TO WALK up a hill with your arms crossed, but Viktoria C.* is trying. Many of the other women—all recent widows from Ukraine—are clumped into groups of two or three, but Viktoria, 42, walks alone. She looks like she's trying to get this part of the day over with. It's morning three of a five-day Climb to Heal program in Slovenia. Here, the women and their children, who were bused from war-torn areas, are hosted by a team of combat veterans, alpine guides, and psychologists from the United States and Europe. While the children are swimming and cliff jumping into the turquoise Adriatic Sea with a Ukrainian diving champion today, the mothers are hiking in the stony karst hills. Trees flank the rocky trail, but sometimes they thin enough to reveal the pale green pastoral landscape far below us of hills, farms, and, farther out, the Gulf of Trieste.

It's a morning of complicated hopes. The mothers show a mixture of exhaustion, relief, skepticism, anxiety, and reserve. Viktoria's neat blonde hair frames a broad face that is both impassive and alert, as if the hillside itself might rebuke her. She wears a gray velour tracksuit and sneakers as she slowly orients her limbs to the trail.

*Last names have been abbreviated to protect participants' privacy and that of their families.

OUTWARD-BOUND

(Below) The Ukrainian war widows and their children spent five days participating in adventure therapy and a reprieve from the stresses of grief and a life lived in near-constant danger.

Amit Oren senses an opening. Petite and no-nonsense, she waves over a translator, and together they approach Viktoria with friendly smiles. A psychologist and assistant clinical professor at the Yale School of Medicine, Oren asks Viktoria if it's okay to accompany her. The woman nods. I join them and we head up toward a ninth-century castle perched theatrically atop a natural cliff buttress overlooking the countryside.

"One of the reasons we're here is to talk about how war and all the losses you've suffered have made you strong, but a little bit hard," begins Oren. "Maybe. Maybe?" She peers into Viktoria's face. "I see your chin moving," says Oren. "I know I touched something deep inside you, because inside you is something different. But outside you present like this ..." Oren crosses her arms and frowns. She's slightly hamming it up. She is old enough to be a mother to these women, and she exudes both warmth and force. She has something to say and she wants them to hear it.

The translator interprets and talks a bit with Viktoria, whose husband, Vitalii, died 16 months ago. She turns to convey that Viktoria is struggling alone with two kids, and her mother is suffering from cancer. Her father drinks too much.

Oren nods. "Let me ask you something," she says. "This is a hard question. How does being angry help you cope with these things?"

"It doesn't," answers Viktoria, "but I'm always mad at myself." She explains she feels angry when she can't cope, or get done what she needs to get done. Oren nods. She is sympathetic, but she's also here to impart lessons in a limited period of time. Most of these women have never received counseling. In Ukraine, psychotherapy generally carries stigma, although that is starting to change in the midst of a grueling war marked by more than three years of ongoing terror and devastation.

Ukraine doesn't release the number of soldiers killed in action since Russia invaded the country in February 2022, but U.S. officials believe it's at least 70,000. The result: an enormous cohort of widows and children navigating grief, trauma, and ongoing danger. The families here traveled by train and bus, escaping bomb shelters and shuttered schools. Some may carry post-traumatic stress; others remain lodged in continuous trauma, their nervous systems constantly primed for the worst.



The families here traveled by train and bus, escaping bomb shelters and shuttered schools.

Along the trail, some of the women stop to take selfies and point to mushrooms. Sunlight filters through the forest canopy. The chirping birds are a surreal change from the air raid sirens back home. Alla K., a blonde, thin, 44-year-old, lost her husband to bullet wounds five months into the war. She still doesn't know how to tell her 8-year-old son, Yevhenii, what happened to his father. Between COVID-19 and the war, the boy has been attending school online for four years. Alla worries he isn't developing proper motor or social skills, and she's paralyzed with fear for her older son, 21, who is now serving in the army.

Rymma B., 38, is a fitness trainer and mother of two whose husband died just before their 16th anniversary. "I keep waiting for his return," she says. "I don't understand how to live on." Natalia N., 44, has seen her village destroyed. She says she has lost her sense of purpose now that her husband is gone. Alona L., 41, often imagines her husband is still inside their house. She worries about their 12-year-old daughter, Veronika, who suffers from constant headaches. All of the women fear for their family's safety.

They didn't know each other before arriving, but this group of 13 mothers and 17 children draws from neighboring cities and villages close to the southern front where Russia has recently gained ground. They are the third cohort of widows brought together by Mountain Seed Foundation, a U.S.-based veteran-led nonprofit whose aim this week is twofold: Imbue the women with positive psychology, and then send them down a cliff-face.

As someone who's spent years reporting and writing about how exposure to gentle green places can help

calm our nervous systems, I'm a believer in the healing power of nature. But I'm wondering if these women are really ready for what's ahead at the end of the week: a rappel off a 300-foot cliff. Some of them have barely left the bomb shelter in many months. Amidst the grief, the trauma, the exhaustion, I wonder whether this sort of adventure-based program can help—and so quickly. So I join them.

OUT HERE IN THE FOOTHILLS, Oren isn't particularly interested in diagnoses, or even talking much about what's happening in their lives. Like me, she is keenly aware of the limits of such a short time frame. Five days, she told me, isn't enough time to open trauma wounds and stitch them back up again. Instead, she teaches simple psychological skills she believes can help improve their daily functioning and begin to shift their mindsets toward something resembling hope.

"Negative feelings like anger constrict our way of thinking," she says to Viktoria. "You're less creative, and it's more difficult to find solutions." Viktoria nods as Oren goes on to explain that positive emotions do the opposite: They broaden possibility.

This is the central theme of Oren's work here this week, a program she calls Permission to Flourish. Heavily influenced by the positive psychology movement launched in the 1990s by University of Pennsylvania scholar Martin Seligman and others, it embraces the idea that facing stressful and even dire circumstances, we can choose to focus on good things around us, lean into our strengths, and find deeper wells of resilience.¹

"Is there anything that makes you feel good?" Oren asks Viktoria.

She answers that she feels proud when her children do well in school, but she's usually too busy to enjoy that for long.

"Ah," says Oren. She puts one hand in front of her, and then the other. "There's light there, and there's dark here. Both are in front of you. Where you choose to look is your choice. When your kids come to you with their achievements, take that one moment and stretch it for five minutes. You can say, in this moment, life is good."

We arrive at the castle. Some of the women stand on a stone wall overlooking the green valley below. Oren gathers the women at the base of the castle, built first to repel Hungarians, then Turks, then Venetians over control of the salt trade in the 16th century.

"When you first came to camp, many of you felt to me like you were closed with castle walls," she says. "A fortress is made to protect, but sometimes we protect too much. Because what happens when you enclose yourself behind a fortress wall? You see this wall in front? It has no opening. You can't see the beauty outside. Opening takes a long time when you're scared. So you start small."

I worry Oren's metaphor is too obvious, perhaps patronizing. At moments like this, the week feels a bit out of sync with reality, like vacation with pep talks. This week the women are encouraged to get massages, take a boat ride, and eat gelato before heading back to the killing drones. Yet these perks lured them here—it was most likely not the opportunity to get therapized. Here was an all-expenses paid chance to get away, give their kids some time to play with other kids (who, not incidentally, are also getting their own adventure therapy through play and rock-climbing), and enjoy some brief periods of the day with no responsibilities. If they started out skeptical of a therapy agenda, they likely still are.

Then again, this isn't standard therapy. "What I do isn't therapy so much as cognitive restructuring," Oren told me before the women arrived. She explained that we are people with habitual thought

patterns, and for most of us, our thoughts tend to amplify sensations of distress in order to protect us from harm. Restructuring those neural pathways is tremendously difficult and takes a lot of effort, she said, but it can be done.

Even so, I had to wonder: Are these life-can-be-good talks reaching them in a meaningful way? Is it too soon?

Positive psychology emerged as a counterpoint to a clinical field focused on pathology, neuroses, and expensive psychoanalysis. As Seligman and Mihaly Csikszentmihalyi wrote in their influential 2000 book, *Positive Psychology: An Introduction*, "Treatment is not just fixing what is broken; it is nurturing what is best."¹



Practitioners champion cultivating optimism, personal strengths, and other factors that maximize well-being. “PERMA-plus” sounds like a breakfast cereal, but it’s a popular model Seligman developed that stands for positive emotion, engagement, relationships, meaning, and achievement, with the “plus” being biological factors such as sleep and nutrition.^{2, 3}

But emphasizing positivity risks minimizing or dismissing the very real suffering and ongoing threats people face. Critics point to the “toxic positivity” of some pop-psych books and Instagram feeds that goad people to embrace happy slogans and exile negative people or emotions. While many studies link an optimistic mindset to good health and professional outcomes (and it’s hard to tease apart whether the relationship is causal),⁴ other research shows that discounting authentic emotions increases mental health risks.⁵

After all, these women, currently in the mountains of Slovenia, are fighting for survival in a way few affluent Westerners, however well intentioned, understand. Oren is aware of the need to acknowledge pain while also encouraging hope. A descendant of Jews who fled Ukraine in the pogroms of 1905, she herself struggles with a tendency to think dark. “I live with a dark cloud, but I also realize I can shift that,” she told me. To this end, she gardens, she walks in nature, she frequently reviews what she’s grateful for. It requires constant practice.

“Probably the biggest piece I teach these women is that, yes, you are in extremely difficult circumstances and you do have to be aware of the dangers, but take a moment to also appreciate the goodness and beauty around you to create a life worth living, not just a life of surviving. We shore up the resources they already have inside them.” She acknowledges the discordance of it all. “It’s a daring attempt with this group in that they have vivid concerns about bombs being thrown at them daily.”

FACING FEAR The idea that courting fear could help those living in a war-torn area seems daring, at best. But psychologists continue to see positive effects of nature adventure-based programs on those who have faced trauma.

The program's aim is twofold: Imbue the women with positive psychology, and then send them down a cliff-face.

Each morning, Oren shepherds the women and children through some breathing exercises and a reminder to find three good things to focus on throughout the day. Then she leads a mothers' discussion group loosely centered around an element of the PERMA model. One day focuses on finding purpose, another on recognizing each woman's particular strengths and how they've helped her cope. One woman says she makes silk flowers for military graves; another volunteers at an animal shelter. Oren encourages one mother to knit socks for her older son's battalion commander. Posters with inspiring quotes from the likes of Viktor Frankl and Audre Lorde ("Caring for myself is not self-indulgence. It is an act of political warfare.") hang on the wall of the hotel conference room.

But Oren also lets the women briefly share their challenges if they want. Viktoria's hardened posture isn't unique. Lena S., 41, whose husband was killed in 2023 during fighting in the eastern city of Bakhmut, says she now has to manage everything alone, including running a small farm. Her friends, she says, aren't there for her. Tetiana H., 47, says she feels like some neighbors and relatives are judging her.

Being tough and self-sufficient are considered laudable traits among Ukrainians. But they are ones that Oren and Mountain Seed co-founder Nathan Schmidt hope to disrupt, at least a little bit. Today, Schmidt, 42, has a bit of a dad bod, reflecting his love for gelato, which he shares with his wife and four kids. During three combat tours as a U.S. Marine in Iraq, he kicked down doors, sometimes destroyed houses while children watched, and helped scorch soccer fields. "The thing I remember most are the eyes of the children," he said. "All they wanted to do was play football. And we took football away."

Coming home, Schmidt wrestled with post-traumatic stress disorder (PTSD), depression, and the moral injuries of war he felt nobody was talking about. Hoping to prevent future wars, he joined the foreign service, getting

stationed in Kyiv shortly after Russia invaded Crimea in 2014. But diplomacy didn't work either, not for eastern European geopolitics and not for his depression.

Then in 2019 a friend took him mountaineering for the first time. It was hard, it was dangerous, it was exhilarating. Suddenly, he didn't feel so numb. He credits those five days with changing his life. "You're in nature with people that you care about, not connected to all the things that stress you out. It woke me to how small I am and the strength in that humility."

Visiting partially bombed out schools in the Donbass region of Ukraine, a new purpose coalesced in his mind: Do something for these kids. Why can't they have an expeditionary experience like he did, a chance to gain some peace, some self-confidence, a new perspective through adventure that they can overcome hardship? "I wanted them to know that they could go through life actually trusting other people—and having a chance to be a kid."

He shares these stories publicly with the widows and their children, and he allows himself to cry when he tells them. It's important to him to demonstrate healthy emotions, as well as to emphasize the power of both nature and community for healing. He knows there's a lot at stake. According to a United Nations report from 2019, as many as 70 percent of children who experience armed conflict are very likely to have at least one psychological disorder.⁶

On the first evening of the week, Schmidt gathered everyone—mothers, kids, mountain guides—in a circle in a hotel courtyard and passed around a long climbing rope so that everyone could hold onto a section. "Now you're on our rope," he said. "And when you're on our rope, you're on our rope. The rope symbolizes community." He gave it a tug. "When you pull the rope, other people feel the rope being moved, right?" Five-year-old Paulina in her pink winter jacket looked at him with big eyes. "We take care of each other when we're on the same rope," he said.



If Oren identifies the positive psychoeducational model as the key element to transforming lives, for Schmidt it's the opportunity to meet physical and mental challenges. The two leaders' approaches are designed to complement each other during the week's program. "I had to be afraid in a controlled environment and overcome it," he said. This component, he believes, enables powerful insights in a limited period of time. Funding from the Buffett Foundation helped enable the nonprofit to run three five-day camps last year as well as develop a year-round climbing gym in Lviv, Ukraine, for military families. This year, Mountain Seed plans to offer many more expeditionary programs, and soon in Ukraine's Carpathian Mountains. But I still doubted if five days away from war and into adventure would really be enough time to make an emotional and psychological difference in these families' lives.

UKRAINIAN PSYCHOLOGIST Alla Shut believes the answer is yes. Her day job in Kyiv is counseling veterans and war widows, and she has also worked with intensive 21-day clinical programs, but she says she sees more transformation here in the mountains.

"I am amazed at what happens in five days," Shut, who was on hand to support the women and children as needed, said. "By the end, they're not exhausted, they're full of this positive energy. They leave feeling what kinds of things that life should be. Here we teach them that even living under the bombing, you should pay attention to this very tasty dessert, this very tasty tea, to this fine weather—because it's impossible for Ukrainians to know if this night will be okay for us or not."

But to the extent that any mental transformation is happening, it is hard to attribute it to the leaders' favorite components. Both approaches—challenges

OVER THE EDGE

Over the course of the five-day program, the widows and their children learned to trust the mountaineering equipment, trust each other, and trust themselves—many enough to take on a daunting 300-foot rappel.

UNDER BOMBLESS SKIES

Positive psychology has gotten its share of scrutiny over the past few decades, but as one practitioner in the Mountain Seed program explains: “Negative feelings like anger constrict our way of thinking.” Positive thinking, on the other hand, can expand problem-solving and creativity.



through adventure sports and positive psychology—are controversial in working with trauma. For the mountaineering, what might have helped Schmidt, a white American man trained in the military, certainly might not help others who experience life-threatening events at much earlier ages and with different identities and in different cultures. Some researchers are questioning whether courting fear is helpful for people with PTSD to experience mindfulness, form new bonds, and gain self confidence.⁷

“That’s a big topic of discussion in the field,” Christine Norton, a professor of social work with a focus on wilderness therapy at Texas State University, told me. “I do think there’s value in overcoming challenge, and realizing, ‘Wow, I’m stronger than I know.’ But it should be invitational, gradual, and with a menu of options.”

Providing both risk and safety is a delicate balance. On day four, the mothers and children head out together to a popular rock climbing area in western Slovenia called Črni Kal. The routes here are near each other, with some lines offering very easy short routes and some more technical ones. By now, after working with instructors all week, the children have grown more confident in their skills. Today is a chance for them to show their mothers what they can do, and for the moms to try some climbs themselves. The tall trees are just starting to turn golden. The grasses are still green; the sky is blue.

Two 12-year-old girls check each other’s helmets. They’ve become friends. Kids coach their moms into climbing harnesses. Valentyna S. unfurls a blue-and-yellow Ukrainian flag. Printed in the center is a photo of her fallen husband, Konstantin. She ties one end under her chin, cape-style. “It makes me feel warm and wrapped up by him,” she says, preparing to climb. “I want to show him what I can do.” Her 15-year-old son, Hlib, watches as one of the guides clips his mother’s harness into a carabiner. She slowly ascends the wall, the flag flowing from her shoulders. She looks every bit a superhero.

The kids and most of the women and the therapists and I all take turns up several short routes. Even some of the mothers who said at first they didn't want to go get excited to try it. I'm amazed to see one mother who seemed very listless earlier in the week infused with a long-dormant athleticism and energy. When they get to the top of the rope, they turn back and smile at their kids below. Alla thought her son Yevhenii would be excited for her, but he turns to her with consternation. For a moment, he didn't know where she was. Now back on the ground, she tries to hug him but he swats her away. Her smile fades. But soon he is off playing with another boy, and she looks relieved.

During a lunchtime lull, Roman Kozicky, a young psychotherapist from Brooklyn, notices some of the children have pulled out their phones. He wishes they wouldn't, but he shrugs. Phones teach us to avoid emotions, he tells me, but climbing does the opposite: It teaches us to respect emotions, and confront them.

Take fear: Humans are supposed to be afraid of heights. All these kids felt it over the first few days. "I can confront this fear I have of falling from a great height," says Kozicky. "I learn to trust the equipment, and myself. And instead of this anxiety holding me back, I can acknowledge it and yet still proceed. It's a reminder that your emotions don't have to paralyze you."

Lanky and playful, Kozicky—whose father's parents were forced out of Ukraine by Nazis and whose mother's parents fled the country under Stalin for New York—speaks Ukrainian and values working these programs. Trained as a clinician in talk therapy, he finds the non-verbal work—things like climbing or tossing a ball or even playing around with pressurized soda bottles in a park—more powerful for kids with trauma. He helps them work with breathing techniques, with posture, with taking small steps. "You're creating your own stability in an environment that is unstable."

There's not a lot of data looking at adventure therapy for people experiencing war-related trauma, but

These women are fighting for survival in a way few affluent Westerners, however well intentioned, understand.

there is some. One study published in *Psychiatry Research* found that a sailing program for Israeli veterans with PTSD led to improvements in quality of life, depression, daily functioning, and hope.⁸ Another, from the journal *Emotion*, found that a whitewater rafting trip led to a reduction in symptoms of stress in dozens of U.S. veterans as well as teens

living in violent parts of Oakland, California.⁹ In a new pilot study run by researchers at the University of Utah, veterans attending five-day wilderness trips showed significant improvements on measures of loneliness, social connection, mood, and perceived stress.

In the rafting study, researchers found that the emotion of awe—more than other positive emotions—triggered the largest mental health benefits. Little is known about how long the effects last. "If one day of rafting gave them a week of well-being benefits, we think after four or five days of really being in the outdoors, you start to show some of the benefits profoundly," said University of California, Berkeley psychologist Dacher Keltner, who co-authored the study. "Where science will be really helpful is to start to chart how much awe do we need to really find deep lasting benefits?"

Researchers are discovering that experiencing awe enables exactly what the positive psychologists talk about, especially a mental reframing of the stories we tell ourselves and a drive toward forming bonds. When we experience collective awe, we feel closer to each other, less lonely, and less consumed by our own problems. Ultimately, these are the conditions necessary for healing war trauma, said Norton. "The experience of powerlessness can become a belief: I am powerless," she explained. "And then that belief, if experienced over and over again, can become a worldview, which is: I have no power in this world. With outdoor adventure therapy, you get to experience some positive emotions you may not have thought were possible. Getting [these participants] back in their bodies, getting them connected to themselves and connected to each other and the natural world is the ultimate way of reorienting toward well-being."

When you're dangling on a cliff face, the present moment eclipses the ruminating mind.

If awe, movement, and nature are really doing the heavy lifting, the specific curriculum here is perhaps besides the point. Rope and castle metaphors might be helpful, but it's also necessary for the moms and kids to feel a glimpse of a new reality in their bodies: a sensorial kind of aliveness.

Plenty of nature-based interventions exist for people suffering from trauma, and the modalities, therapies, and activities are all over the map. Another program for Ukrainians called Metta NGO employs a four-day structure in the Carpathians, and it has served about 500 veterans, widows, and parents of fallen soldiers. Rather than being “challenged” per se, participants spend time hiking, doing mindfulness exercises in nature, and singing and talking around a campfire. They can also elect to have sessions with therapists through the program.

“We use a combination of cognitive behavior therapy, EMDR [eye movement desensitization and reprocessing, often used to treat trauma], and somatic experience therapy,” said co-founder and therapist Yulia Stadnytska, who is based in Lviv. But the biggest factors in healing, she believes, are the peer-to-peer support and just being outside. “In nature, everything has a cycle and a process,” she said. “This message is very powerful to give permission to grieve at your own pace, in your own process. It's not a forced message from a social environment. For them, just hiking and talking means more to them than a particular psychologist saying this technique or that.”

The time outdoors might resonate particularly strongly with Ukrainians, Stadnytska said. “We are still an agricultural country,” she said. “We have a lot of gardens, we plant seeds, many Ukrainians have grandparents who farmed, and many of the population likes to go to the mountains and the forests.”

BY FRIDAY, OUR FINAL DAY in the field, nine of the 13 mothers decide to go for the big culminating activity of the week: the 300-foot rappel. The whole group, including the kids, walks up to a meadow at the top of a cliff outside the town of Istria. It's filled with golden grasses, yellow groundsel blossoms, rosy shrubs. The families wander the hillside and unpack their sandwiches. One of the moms, Olena R., surprises another, Valentyna, with a hand-gathered bouquet. She leans down and hugs her and together they sit in the sun, laughing.

Soon it's time to cinch up the harnesses and walk to the edge of the chasm from which we will start the long, two-pitch rappel. It looks impossibly far to the ground below, which we can't even make out, although we know Schmidt will be there to ease the landing and offer high fives. The women gather around each other for pictures and raucous Ukrainian cheers, one of which ends with telling Putin to go screw himself.

Ruslana M. is the one wearing a Ukrainian flag today. She wants it for strength. Her 12-year-old daughter, Leeza, gives her an excited hug and wishes her the best. Then the guides offer encouraging words and instruction to keep leaning out over the abyss as Ruslana holds the top rope. Standing at the lip, testing her weight on the rope, she looks terrified. She starts and stops several times. I wonder again if this is a good idea. I see her close her eyes and breathe, practicing the box breath Oren taught her. She plants one foot on the karst rock, then the other below, and slowly disappears over the edge.

Waiting for our turns, Olena tells me she was afraid yesterday but feels brave today. She feels calm. She stares at a picture of her husband on her phone. His name is Aleksander. He's tall and bearded, standing in a field of cornflowers, wearing a sly smile. She kisses the picture and quickly puts the phone away. She walks to the lip and, with help from the team, hooks herself to the rope.

I follow them down, heart hammering. There's no choice but to accept that I'm dangling from a rope high above the ground. It's an exercise in surrender. I realize just how much of the positive-psychology dogma naturally emerges when you're dangling on a cliff face. The present moment eclipses the ruminating mind. Focus on where your foot lands. Trust it's going to work out. This moment, like every moment, has a beginning, a middle, and an end. Keep going. And then I notice the lichen on the wall, the warm air on my shoulders, the feel of my legs in the harness.

At the bottom, there's Schmidt—quintessential dad—waiting with a hug. The other women who have descended seem relieved and also a little drained. Everyone looks up in awe at the sheer face of the wall we've just rappelled. It all would have been impossible to imagine a week earlier. Iryna S., a mother of two boys who are also about to defy gravity, captures the moment later when she says, "The descent from the mountain was an explosion of emotions for me. I was terrified but also very curious. I want to experience such emotions in everything I do."

It's the last meeting, and the women are writing notes about what they've learned. They look different. More relaxed, but also more engaged. They're not just telling Oren what she wants to hear. Their faces are so complex. I see the yearning, the problem solving, the real affection they've developed for one another. They will stay in touch now, and some will seek further counseling with help from Mountain Seed.

In Olena, writing her notes, I see so many layers in those gentle contours, centuries lived in the lifetime of a woman. Her face will stay with me for weeks. I will see her kissing her husband's photo. I will see her crying, then laughing, bestowing her new friend with flowers from a peaceful field in the sun. ☺

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The Unnatural History of Bird Flu

H5N1 is a human creation

BY BRANDON KEIM

SINCE THE COVID-19 PANDEMIC, few scientific questions have received as much public attention as the origin of the deadly virus: people or nature. It was the subject of journalists' investigations and government hearings and academic recrimination; it became part of the culture war. It is perhaps strange, then, that little attention is paid to the role people have played in another potential pandemic virus: H5N1 avian influenza, a creation of modern poultry production systems.

The earliest forms of H5N1 were identified nearly three decades ago in Guangdong, China, a region rapidly adopting the industrial husbandry practices common to North America and western Europe. A subsequent outbreak in Hong Kong infected 18 people, six of whom died; the virus did not transmit easily between humans and was soon contained, but H5N1 was not extinguished. Since then, it has spread around the planet, leaving mountains of chicken carcasses in its wake, and also silent seabird colonies and beaches covered with dead seals. H5N1 has killed 464 people so far—not a large number, but the possibility of it becoming better at infecting humans is ever-present. The historical precedents are grim.

The first modern influenza pandemic, in 1918, killed an estimated 50 million people. Several million people died in the pandemics of 1957 and 1968, and the 2009 H1N1 pandemic killed about 350,000 people in its first year. During the latter pandemic, the virologist Yi Guan—renowned for helping contain the 2003 SARS outbreak—said that if H1N1 and H5N1 mixed, he would “retire immediately and lock myself” in a high-security lab for protection. And as the Covid pandemic showed, even a disease with relatively low mortality rates can be cataclysmic.



In 2021, H5N1 reached North America, setting off a viral blaze in poultry—more than 150 million chickens and turkeys have been killed to date, either by the virus or in efforts to curb its spread—and infecting both wild birds and mammals at unprecedented rates. H5N1 is now rampant in cows, a species not previously known to be infected, raising fears that viruses adapting to them might become more infectious to humans.

That sort of adaptation is even more likely, of course, when H5N1 spills into humans, which is happening with disturbing frequency. In June 2024, a total of three H5N1 infections had been reported in the United States; seven months later, that number stood at 67. Although symptoms remain mild, and the virus still does not transmit easily between us, scientists are spooked. Those I talked to for this story used phrases like “red lights flashing,” “totally novel ballgame,” “no hope of containing,” and “under attack.”

Media coverage of H5N1 captures this urgency but tends to focus on the day-by-day—the latest “depopulation,” as mass exterminations at poultry facilities are known, the latest sick cows or dead cats, the latest mutations. Lost in the furor is a clear sense of where H5N1, and the class of influenzas to which it belongs, comes from: the evolutionary crucible of intensive animal production.

In the facilities—the artificial ecosystems—that now house much of Earth’s terrestrial vertebrate biomass, constraints on virulence that prevail in natural ecosystems are not merely removed. Virulence is actually favored. In the words of Mark Woolhouse, an epidemiologist at the University of Edinburgh, the viruses are “a response to the selection pressures that exist in a human creation: the modern poultry farm.”

EACH SPRING MILLIONS OF BIRDS gather at Lake Chany, a 660-square-mile shallow lake and surrounding wetlands in the steppe of southwestern Siberia. The complex supports an estimated 20,000 waterbird populations—not individual birds, but entire communities—whose migratory routes span much of Africa, Europe, and Asia. To a virologist this is as much a gathering of influenza, which is ancestral to birds and especially waterfowl.

“There was continual influenza virus circulation in waterfowl long before humans even existed,” says Jan Slingenberg, a now-retired disease ecologist who once worked for the United Nations Food and Agriculture Organization, where he headed a program that helped member countries control emerging animal-borne diseases.



NATURAL STATE Avian influenza viruses are endemic in wild aquatic birds, with whom they have coevolved for millions of years. They cause minimal disease; damaging their hosts would impair their own spread.

When I ask Slingenbergh about influenza evolution, he starts by describing Lake Chany and how, for one month each year, after the breeding season ends and before autumn migration begins, flu viruses emerge from dormancy and replicate in the far end of the birds' gastrointestinal tracts. After being defecated into the water the viruses are picked up by other birds, who will soon carry them far and wide. That exquisite timing, what Slingenbergh calls the “finesse and subtlety” by which influenzas merge with the birds' life history, speaks to millions of years of coevolution. So does the fact that—at least until recently—influenzas caused almost no disease in their avian hosts.

“The virus has evolved beyond requiring damage to the host,” explains Slingenbergh. “It is a dream scenario

that would have fascinated Darwin.” The viruses do continue to evolve: As those trillions upon trillions of virus particles replicate in Lake Chany's waterfowl they accumulate mutations and even swap gene segments. Nevertheless they remain pacific; infections do not damage tissue, and infected birds show few symptoms.

This makes intuitive sense. Viruses that leave birds healthy, moving about and flying halfway around the world, reproduce more than viruses that endanger their hosts and thus limit their own opportunities. If a strain turns deadly or incapacitating, it ultimately harms itself. Survival of the fittest in this case means doing no harm. “This is the starting point. This is where we come from. This is the default host-virus interactivity scenario,” Slingenbergh says.

DELMAS LEHMAN / SHUTTERSTOCK

Eighty-five percent of all eggs come from operations containing between 50,000 and 6 million hens.

Scientists call these viruses Low Pathogenic Avian Influenza (LPAI). Should a strain evolve to be extremely harmful in chickens, it's classified as Highly Pathogenic Avian Influenza (HPAI). Those descriptors, it should be stressed, refer to their consequences for chickens; an HPAI that kills a flock in a few hours might cause no problems for a human, and vice versa. LPAIs can be quite dangerous to us, as with an H7N9 strain that emerged in China in 2013, infecting at least 1,568 people and killing 616 of them even as it went undetected in poultry farms.*

With that said, HPAIs are uniquely concerning. They tend to infect birds' respiratory tracts and become airborne, and the sheer number of viral particles generated by an infection raises the chance of an exposed human catching it, even if the virus is not very contagious to us. Meanwhile, every replication rolls the dice on a virus acquiring a mutation that pushes it closer to human infectiousness. It's a numbers game. And if an influenza strain infects someone—or a pig, a species routinely described as a mixing vessel for flu—already

infected by another strain, the strains might exchange genetic material, producing a new variant that combines the worst of each.

None of this is guaranteed to happen, but it becomes more likely when an LPAI strain evolves into an HPAI—an evolutionary jump documented 39 times between 1959 and 2016. Thirty-six of those jumps were reported in commercial poultry production systems.** Of the other three, one was detected in wild terns and two in backyard chicken flocks, both of which were located in regions of intensive poultry production—suggesting that the highly pathogenic strains spilled into the backyard flocks rather than originating there.

“This was most frequently happening in commercial settings,” says Marius Gilbert, an epidemiologist at the Free University of Brussels who analyzed the incidents.¹ Although Gilbert acknowledged that detection bias could explain the pattern—it's easier to dispose of a few dead backyard chickens without attracting notice than to bury several thousand—and HPAIs could conceivably arise unnoticed in small flocks and make their way into large

* For the sake of convenience, flus are named after two of their eight genes—the H for haemagglutinin, of which there are 18 variations, and N for neuraminidase, of which there are 11 types. Hence H5N1, H7N9, and so on. Those two genes are especially important as they shape how a virus particle attaches to a host cell and replicates itself.

** Three more LPAI to HPAI conversions have occurred since 2016, all in commercial poultry.

operations, he does not think that happened. In commercial systems, Gilbert says, “you facilitate the Darwinian selection from an LPAI into an HPAI.”

In intensive poultry production facilities—factory farms, in everyday language—thousands of birds are packed together, making it easy for pathogens to pass between them. Their immune systems may be suppressed by antibiotics and environmental stresses: toxic air, overcrowding, lack of sunlight, physical deformities induced by breeding for accelerated growth, and their own cacophony. The birds are also genetically similar, meaning that a virus capable of evading one bird’s defenses can probably evade many of them.

The conditions are ripe for a virus to spread—and speed is at a premium. A century ago, chickens were killed for meat at about 16 weeks of age; nowadays that number is closer to six weeks, and sometimes just four. “We’re turning over these birds faster and faster. And there’s an evolutionary argument that the shorter-lived your host is, the more virulent you can afford to be, because you might not kill it by the time it’s died anyway,” says Woolhouse. With so little time available to transmit and replicate, a virus that moves slowly is at a disadvantage.

“The virus responds to those pressures, and the consequence of that is to become more virulent,” Woolhouse says. He and infectious disease modeler Katherine Atkins, also at the University of Edinburgh, studied those dynamics in Marek’s disease, a viral affliction of poultry that has become more virulent in the past several decades. Their findings don’t *prove* that rapid turnover times drove virulence, he says, but “the data were consistent.”

Gilbert pointed to several studies that complement these observations and proposed mechanisms. In one, researchers conducted a “serial passage”—infecting a chick, taking the resulting virus and infecting another chick with it, and repeating—that mimics what happens in commercial systems.² The original flu strain came from wild swans, didn’t infect chickens well, and didn’t harm those it did infect; within a couple dozen generations it had a 100 percent mortality rate. In another study, researchers tracked LPAIs evolving into HPAIs on farms in northern Italy—a process documented in even more granular detail on a single farm in the United Kingdom in 2008.³

Now all the pieces are there: the landscape-scale correlations between commercial settings and pathogenicity; mechanisms to explain these correlations; experimental demonstration; and on-the-farm observations. Put them together, says Gilbert, “and you have a full story.”

A CENTURY AGO, the average American chicken flock contained 70 birds. It was a time of backyard coops and small farmers, before consolidation and vertical integration and the methods that accompanied them. Nowadays the 9 billion chickens slaughtered for meat each year in the U.S. are raised in buildings containing, on average, 20,000 or more birds, with roughly one square foot of space apiece. Even cage-free facilities often house between 50,000 and 75,000 chickens, and 85 percent of all eggs come from operations containing between 50,000 and 6 million hens. As for pigs, the average herd numbers more than 1,000 animals.





MODERN CHICKENS An estimated 70 billion chickens are killed for meat every year. In developed countries, the chickens typically live in facilities like this broiler farm in northern Italy.

“If we wanted to design how to make great virulence, this would be how.”

“If we were to get our drafting table up here, and we wanted to design how to make great virulence, this would be how,” says Rob Wallace, an evolutionary ecologist and author of *Big Farms Make Big Flu*. “The sky is the limit.” Wallace suggests we think of poultry not only as food for humans, but as “food for flu.”

In 2009, Wallace wrote a paper in the journal *Antipode* entitled “Breeding Influenza: The Political Virology of Offshore Farming.”⁴ Although there are hundreds if not thousands of scientific papers analyzing the genetic origins of H5N1 since it was first detected in 1996 in Guangdong, China, Wallace’s account is among the few to describe the social and economic context of its emergence.

For centuries, Guangdong, a coastal province, had been known for poultry production, with flocks of domestic ducks, geese, and chickens raised side-by-side with wild fowl in a mosaic of rice paddies and small ponds. Industrial farming methods arrived in the 1970s, and the burgeoning intensification accelerated as China slowly embraced capitalism and opened some regions to foreign investment. Just as Shenzhen, then a small city in Guangdong, became a center of electronics manufacturing, other parts of the province became hubs of modern poultry production; poultry exports swelled from \$6 million in 1992 to \$774 million in 1996, and chicken production doubled in that time. Many of the province’s 700 million broiler chickens lived in operations housing 10,000 or more birds.

In a xenophobic era, this is a potentially sensitive topic, and Wallace stresses that blaming China or

Guangdong’s farmers is misleadingly simplistic. “Foreign direct investment coming in from different places around the world—London, Hong Kong, New York—basically helped drive the shifts” in animal production, he says. And of course the model they supported was developed in the U.S. and western Europe.

Guangdong was a particularly risky place for this to happen. Already the region was known as a hotbed of influenza, which circulated year-round between domestic birds and their wild kin; it’s also part of a bird migration corridor between Arctic breeding areas and wintering territories in South Asia and the Indonesian archipelago. When a University of Hong Kong virologist named K.F. Shortridge surveyed Guangdong’s poultry markets in the early 1980s, the extraordinary diversity of influenza viruses he found there, combined with the region’s dense human populations intermingled with domestic and wild fowl, led him to write that Guangdong “would be an ideal situation for an avian influenza virus to cross the species barrier to man.”

In the spring of 1996, in the town of Sanshui, about 50 miles west of the capital of Guangzhou, an outbreak occurred in farmed geese. Scientific accounts provide little detail, but one mentions that “symptoms included bleeding and neurological dysfunction.” The mortality rate was 40 percent. Virologists tested the birds and identified the culprit: an H5N1, not previously documented, which they called influenza A/Goose/Guangdong/1/96 (H5N1).

Later analysis showed that it likely descended from a low-pathogenic strain that somehow found its way

into poultry, in whom it became highly pathogenic after evolving to attack many cell types rather than a few. For the moment, though, no more outbreaks were reported. Influenza surveillance programs failed to detect the strain elsewhere, a calm that lasted until the following spring, when a virus from the same lineage burned through several poultry operations in Hong Kong. In the interim, it had reassorted with other strains and become even more transmissible.

The symptoms were horrific. Infected birds bled from their tracheas and rectums, turned blue from oxygen deprivation, and hemorrhaged internally. The virus also infected humans. The first victim was a 3-year-old boy admitted to a Hong Kong hospital in May; his lungs filled with fluid, his brain swelled, his kidneys and liver failed, and within days he was dead. In December, 17 more people became infected. Five died.

This was shocking, and not only because the disease was so severe. Avian influenzas were not supposed to infect humans *at all*. The infections “reshaped the central dogma of influenza ecology, which used to indicate that influenza A virus must first adapt to swine ... before infecting human,” wrote Xiu-Feng Wang, a virologist at the University of Missouri.

Fortunately that strain did not transmit easily between humans. The cases were traced to exposures in Hong Kong’s poultry markets, and authorities ordered the immediate slaughter of 1.5 million birds and suspended all live poultry trade. They succeeded in stopping the outbreak—no more human cases were reported, and the strain was seen only once more. But other descendants of the original H5N1 had quietly become established in domestic geese. They would spawn an influenza unlike any other.

BETWEEN 2001 AND 2003, H5N1 continued to cause sporadic outbreaks in domestic and wild birds. In 2004, it surged across east and southeast Asia, and though only two human infections were reported, fears grew that it might adapt to us. “We are talking at least 7 million” human deaths, warned Shigeru Omi, the World Health Organization’s western Pacific director, “but maybe more—10 million, 20 million, and the worst case, 100 million.”

H5N1 did not then acquire the traits necessary to make Omi’s forebodings come true, but it decimated

poultry in Thailand and Vietnam, where more than 100 million domestic birds died from the virus or were killed in control efforts. In May of 2005, H5N1 caused a mass die-off of wild bar-headed geese and other birds in China’s Qinghai Lake, an important migratory stop-over point. The outbreak was initially blamed on wild birds, although goose farms were later implicated, too. Migrating birds soon carried it across the continent.

Within months, the Qinghai lineage of H5N1 spread across northeast China, northern Mongolia, and southern Russia. The virus was not always so deadly to wild birds as it was to domestic fowl, and so the region’s vast waterfowl breeding areas amplified its spread, which by 2006 also included much of Europe, the Middle East, and Africa. Already the panzootic—meaning pandemic, but in non-human animals—was recognized as unprecedented. It was just getting started.

Over the next decade, H5N1 proliferated through Eurasia and Africa. It diversified in dizzyingly complicated ways; the original H5N1 trunk branched into a great tangled phylogenetic tree as mutations and genetic segments from other strains accumulated.⁵ It gave rise to the so-called H5NX viruses—H5N2, H5N3, H5N5, H5N6, H5N8, H5N9—which evolved on their own trajectories and spawned new forms that crossed with the old ones. A web of influenzas descended from H5N1 now covered the world, frightening scientists and public health officials who sounded alarms and tried to contain the spread.

But containment was a Sisyphean task. Viruses teemed in the bodies of dead birds and also in their waste, which is often spread as fertilizer on farmland. There it can survive for months, exposing foraging birds and leaching into streams for waterfowl to pick up. Stricter security and hygiene at animal production facilities helped, but it’s practically impossible to sterilize every surface, much less seal buildings from the outside world. During a 2004 outbreak in Kyoto, Japan, H5N1 was found on nearby flies; during the U.S. outbreaks of H5N2 in 2015, infections were linked to the airborne spread of viral particles emitted by the ventilation systems of Midwestern poultry operations. And though wild birds carried H5N1 and other flu strains across long distances, regional spread between farms was driven primarily by the poultry trade.



By the late 2010s, two of those H5NX offshoots, H5N6 and H5N8, had supplanted H5N1 worldwide. But in 2021, a new H5N1 subtype underwent what virologists called an “explosive geographic expansion” across Europe, Asia, and Africa. In northwestern Europe, it caused mass die-offs in sandwich tern colonies, killing an estimated three-quarters of the breeding population, and nearly every chick born that year, in just two months. That December, it killed 360 of 419 birds at a small farm in St. John’s, Newfoundland, marking the arrival—at long last—of H5N1 in the Americas.

It spread south and west, once again branching and diversifying.⁶ By the end of 2022, more than 50 million U.S. poultry died from the virus or were culled; veterinary scientists refined techniques for killing hundreds of thousands of birds as quickly as possible. Wild birds

were afflicted, too, and in early 2023 H5N1 killed more than 200,000 cormorants, boobies, and pelicans off the coast of Peru in early 2023. Not long after, one-fifth of condors in southwest California died, and people scrambled to immunize the endangered vultures. Altogether, H5N1 has afflicted more than 200 bird species in North America and 400 bird species worldwide.

Some strains also demonstrated a newfound propensity for infecting mammals.⁷ Pinnipeds have been hit especially hard: In the summer of 2022, hundreds of harbor and gray seals in New England died from H5N1, and the following year, more than 24,000 sea lions perished along the western coast of South America. At an elephant seal colony in Argentina, H5N1 killed more than 17,500 seals, including 95 percent of all pups.

DISEASE CONTROL (Left) A worker from Israel's Ministry of Agriculture and Food Security uses a forklift to transport turkeys killed during a 2006 outbreak of highly pathogenic avian influenza in Holit, Israel.

Those and other tabulations of H5N1's wild animal mortality are by all measures a vast undercount, perhaps by orders of magnitude, as most wild animals die without being found. H5N1 is a full-blown conservation crisis.⁸ What keeps it in the news, though, is—beyond rising egg costs—the threat to humans. From that perspective the most worrisome aspect of the elephant seal die-offs was how the seals didn't simply catch H5N1 from nearby birds. They transmitted it to each other, suggesting an ongoing refinement for mammalian immune systems.

"The more chances this virus gets to replicate in mammals, the more pressure there's going to be to change in ways that make it more risky for humans," says Richard Webby, a virologist at the St. Jude Children's Research Hospital. Webby worries about H5N1 spreading in pigs, those ideal mixing-vessels. That hasn't yet happened, but in just a few years the virus has been detected in 30 mammal species in the Americas—more than it infected worldwide in two decades prior. "The altered ecology of H5N1 has opened the door to new evolutionary pathways," wrote scientists reviewing this expansion in the journal *Nature*.

Some of those pathways involve cows, a species not previously known to be infected by H5N1. The first bovine outbreaks occurred in early 2024, in dairy cows in Kansas and Texas; how they acquired it is unknown, but one possible culprit was the practice of feeding chicken carcasses and their excrement to cows. That had continued, along with the use of chicken waste as fertilizer, as H5N1 spread. The virus also infected the cows' udders, an unheard-of trait for influenza. "That is something no one would ever have predicted," says Slingenbergh. The mortality rate was fairly low—infected cows tended to lose their appetites and produce less milk—but half the farm cats who drank the milk died, and preliminary research raises the possibility that cows are better influenza mixing vessels than expected.

H5N1 is a full-blown conservation crisis.

Within months, H5N1 was found in milk samples from 12 states, suggesting how fast it was spreading. As of early 2025, H5N1 had been detected in 959 herds in 16 states, a number widely considered an undercount. As for chickens, H5N1 had been found in 1,490 poultry flocks spanning every U.S. state, with 150 million birds killed by the virus or to control it.

The number of human infections swelled, too. As of June 2024, the U.S. Centers for Disease Control and Prevention had documented three cases; by late January of 2025, that number had grown to 67, of which 63 were traced to cow or poultry exposures. (As most farm worker infections go unreported, the actual number is very likely higher.) So far symptoms have remained mild in humans: fever and body aches, congestion, conjunctivitis.

This contrasts with earlier stages of the H5N1 panzootic. Between 2003 and 2021 the World Health Organization documented 862 human cases worldwide, with 455 deaths. Many cases likely went undetected, meaning the actual fatality rate was far lower—but even taking that into account, the strains that proliferated in the Americas do seem less harmful, at least for now.

One person, a 65-year-old woman from Louisiana who contracted H5N1 from chickens, has died in the current outbreak. When researchers compared the viruses in her to those from her flock, they found new mutations linked to respiratory tract infection

“I’m always surprised we don’t have more outbreaks. The system is so broken.”

and transmission. The mutations likely arose as the virus replicated within her—a sobering reminder that although current incarnations of H5N1 are not a significant human threat, they are constantly changing.

“There are two things we don’t understand at the moment,” says Gilbert. The first is, why are human infections in the U.S. mild compared to those witnessed during the Asian H5N1 poultry epidemics. “The second question mark is, ‘What does it take?’” Meaning: Will H5N1 become highly lethal in humans?

IN MARCH 2009, a then-novel H1N1 influenza emerged in Mexico. The outbreak’s exact origin remains unknown, but the first cases occurred near industrial pig operations; genetic analyses showed links to flu strains that evolved in factory pig farms in the U.S. and western Europe, and spread via trade. In the year that followed, an estimated 12,000 Americans died from H1N1, and 350,000 people worldwide. At the time, I reported stories about poor livestock surveillance and shortfalls in antiviral drug production for humans. It didn’t occur to me to ask: If so much death is the cost of eating pigs, why eat them at all?

Fifteen years later, having mostly stopped eating animals—primarily for their sake, but environmental problems and disease risks are factors, too—this framing seems obvious to me. Perhaps that is simply my bias now. But even if it’s unlikely that many people will go vegan in the near future, a reckoning is overdue. “The very biology of influenza is enmeshed with the political economy of the business of food,” wrote Wallace in his account of H5N1’s origin decades ago in the fast-industrializing poultry systems of Guangdong.

That sensibility is not to be found in the ongoing H5N1 discourse. The news is constant—in the days it took to write this story’s final draft: H5N1 was reported in 22 U.S. poultry operations, including a Pennsylvania egg farm with 1.98 million chickens; a second cow-infecting H5N1 strain was detected; New York City

closed its live bird markets; the CDC posted news of people catching H5N1 from their cats, then deleted it; and the CDC’s H5N1 policy chief resigned—but fragmentary. More in-depth stories call for better disease monitoring, vaccines, and therapeutics, and chronicle the debacle of America’s institutional responses. Scientists emphasize the control and treatment of H5N1—which is unquestionably, desperately needed, and may save thousands or even millions of human lives if it evolves to easily infect us. The essential conditions that give rise to dangerous new influenzas, however, are rarely challenged.

There is a “frustrating lack of appreciation of the social and economic drivers of industrialisation and the inevitable effects on infectious disease emergence and transmission,” says Stephen Hinchliffe, a geographer at the University of Exeter.

Perhaps some of that traces to what Hinchliffe and colleagues, writing last summer in the journal *Royal Society Open Science*, called “a founding myth of industrialized agriculture”: the idea of animal production units as self-contained and their pathogen flows controllable.⁹ That myth was dispelled scientifically long ago, but it retains power. I also wonder if another psychological factor is involved: a reluctance to confront the realities of animal production.

Early in the Covid pandemic, researchers led by Kristof Dhont, a psychologist at the University of Kent, surveyed several hundred people on their attitudes toward meat consumption and pandemic risks. Those who most enjoyed meat, who couldn’t imagine replacing it in their diets, were least likely to believe that factory farms caused disease—and when informed of risks, they tended to dig in and reject reforms that would reduce those risks. “People hold beliefs about meat in a protective manner and engage in a range of justification strategies,” wrote Dhont and colleagues.¹⁰ “Having a commitment to eating meat poses a barrier to recognizing the real-world contribution of factory

farms to zoonotic disease risk.” All the usual social science caveats apply—it was only one finding, in a relatively small group—but there is plenty of research on the cognitive biases of animal consumption, and no reason to think scientists should be immune to them.

Meat is a particularly nuanced topic. Slingenbergh, who produced a United Nations report on the disease risks of animal production, felt conflicted when talking about those risks. His agency’s mission was to end starvation and malnutrition; the risks had to be weighed against the benefits for hungry people. “I was very cautious in saying aloud that the way farmers are producing animals should be considered integral to the wider problem” of disease, he says.

Wallace calls for industrial livestock to be replaced by agroecological systems in which meat comes from networks of small, locally owned farms whose practices are less likely to intensify disease. Gilbert agrees that this approach should help prevent the emergence of more virulent pathogens, and also be better for the environment and the people involved—“but of course this goes against economic forces,” he says.

In the last several decades, livestock industries in developed countries have consolidated dramatically, with fewer companies controlling ever more market share. Profit-maximizing intensive production methods go hand-in-hand with this shift. International banks continue to pour money into factory farming; even in their absence, regional banks are a source of funding.

“I’m always surprised we don’t have more outbreaks,” says Jay Graham, a public health scientist at the University of California, Berkeley, who has studied H5N1 in Thailand and farming in Ecuador. “The system is so broken.”

It’s difficult to imagine the system changing. Yet imagination is demanded, all the more so because the shift to industrialized animal production is far from complete. Though factory farming is established in developed countries, many middle-income nations are just now making the transition, and poorer countries are expected to follow. “There’s going to be lots of issues around this, because industrial ag is just taking off,” says Graham.

With luck, H5N1 will pass humanity by without ever becoming both virulent and contagious among us. Perhaps those strains now endemic in wild animals

will revert to milder forms. But even if that happens, the threat of influenzas made more dangerous by our own activities will remain. Intensive animal production “is where virulence, aggression, and host damage has found a place in virus transmission success,” warns Slingenbergh, now free to speak his mind. “And we haven’t even begun to grapple with this.” 🌀

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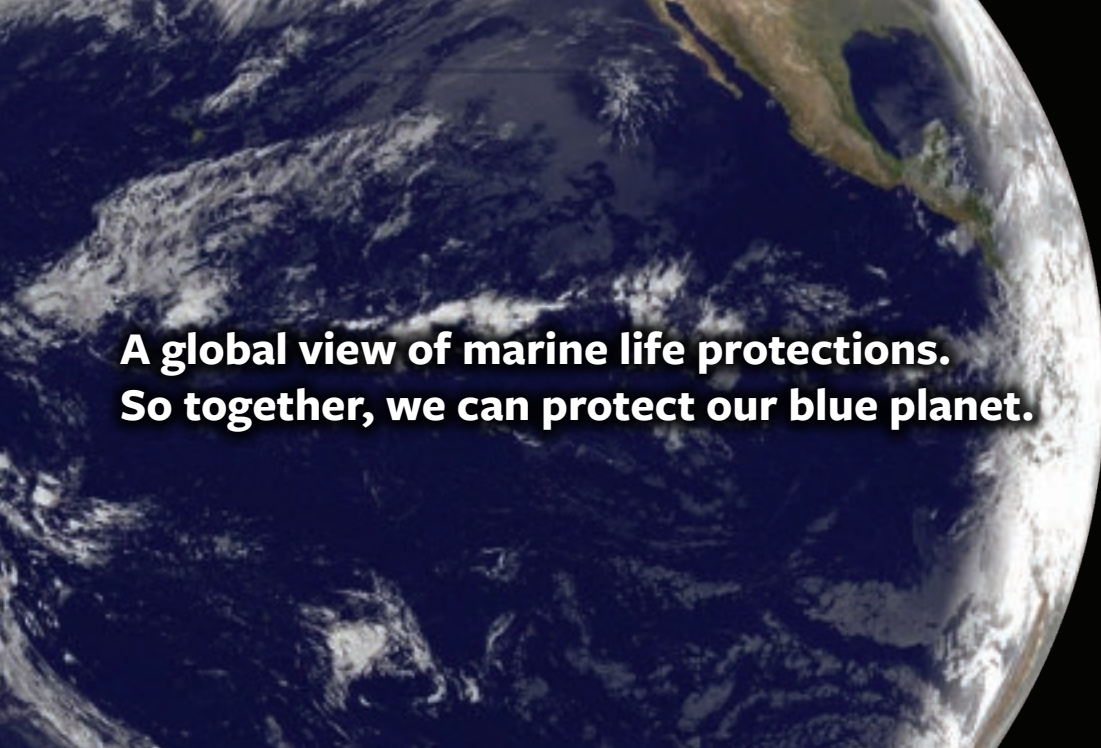


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220
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41
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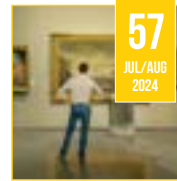
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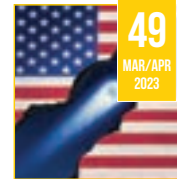
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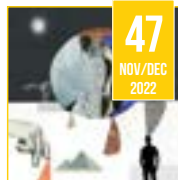
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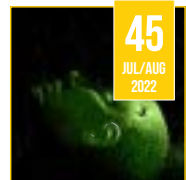
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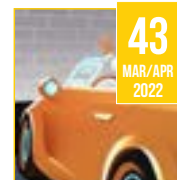
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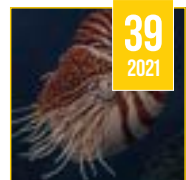
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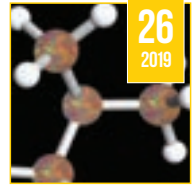
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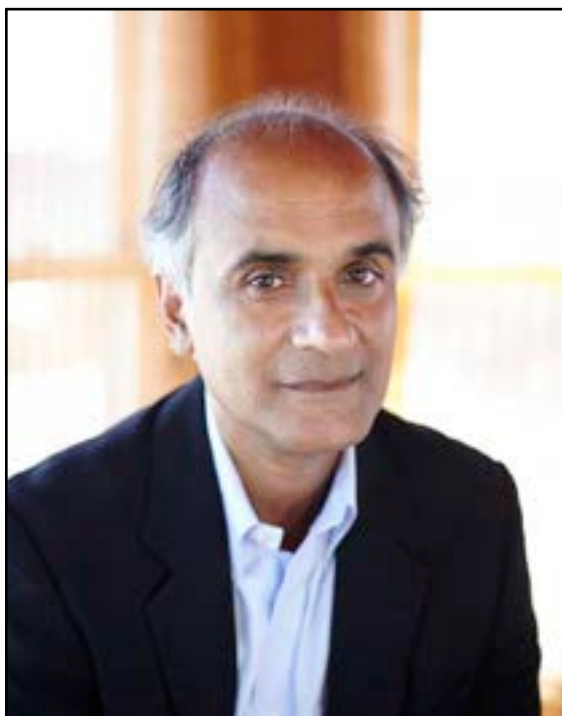


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PICO IYER

*The author of *Aflame* on finding strength in silence and imbuing optimism with realism*

INTERVIEW BY NICK HILDEN



THE UNIFYING POWER OF WIDE-AWAKE SILENCE

I've never seen the world so divided as it is now, and part of me feels that words and beliefs can cut us in two, even as silence—which lies on the far side of them—can sometimes bring us together. I've made more than 100 retreats in a single hermitage because the people I meet there are the most open-minded I've met and are most committed to finding the places and feelings we have in common, not the ones that tear us apart. And every time I travel into this wide-awake silence, I receive a powerful infusion of hope and confidence. Places of quiet will always be valuable in a world of distraction and acceleration.

BUILDING AN INTERNAL SAVINGS ACCOUNT

Traveling into silence is a way of replenishing my inner savings account, my internal resources. Which in many ways are all I have to draw on when I step into an ICU. As I was writing my book *Aflame*, my mother had a stroke and was rushed into the intensive care unit for 35 days. As I was sitting by her bedside and she was teetering between life and death, I realized that my resume was no help at all. All the books I'd written were of little use. My bank account was of limited use. The only thing I could draw on to help her—and myself—was whatever I had gathered by sitting quietly, building up my inner reserves. We all have to make a living, but it will only be as rich and strong as the life we've built beneath and around it.

OPTIMISM IS ONLY AS USEFUL AS THE REALISM IT'S BASED ON

My sense is that optimism is only as useful as the realism it's based on. I like the fact that two of the great hope-givers I know—the Dalai Lama and his great late friend Archbishop Desmond Tutu—both stress that they're not idealists or romantics or even optimists; they've lived close enough to suffering and difficulty not to expect life always to be sunny or amenable to their plans. But they do believe that our end is not despair and that the arc of the moral universe, as Dr. Martin Luther King, Jr. put it, bends toward justice.

We've all suffered traumas and horrors that to some extent never go away. But a life without hope is no life at all. There are so many causes for despair right now, from warfare to the climate crisis to our mounting divisions to our recent plague. But the world has improved in so many ways in my lifetime, and often in ways that we quickly take for granted. It's up to us whether we concentrate on what cuts us up or what opens us up. ☺

DEREK SHAPTON

*“Shall we educate ourselves
in what is known,
and then casting away
all we have acquired,
turn to ignorance for aid
to guide us among the unknown?”*

—Michael Faraday, Lectures on Education, 1854



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in the Complexity
of Evolving Worlds

Image: Bates Hall, Boston Public Library – Established in 1848, the Boston Public Library was the first large, free municipal library in the United States. Photograph by Charles Pollock, 1895.

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