DISTILLATIONS

STORIES FROM THE SCIENCE HISTORY INSTITUTE'S ONLINE MAGAZINE

BEST OF— VOL. 3

A Cold Day in Stockholm

DISTILLATIONS

STORIES FROM THE SCIENCE HISTORY INSTITUTE'S ONLINE MAGAZINE

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Letter from the President

Since 2022 the Science History Institute has served as the institutional home for the History of Science Society (HSS). For historians of science, this is a milestone year, marking a century since the creation of HSS in 1924. George Sarton, a Belgian chemist-turned-historian, was the principal founder of HSS and a passionate early advocate for the history of science. Sarton was a vocal proponent of this nascent field as an academic discipline, but he also encouraged its practitioners to engage audiences beyond academe—to awaken the general public to the concept that science has a past as well as a present and future.

Sarton had an expansive view of the field's potential, arguing that his fellow historians should forge connections between science and the humanities and, in so doing, build what he termed "the new humanism." The history of science, he believed, should illustrate the "gradual unfolding of truth, in all its forms, whether pleasant or unpleasant, useful or useless, welcome or unwelcome."

While the Institute provides a Philadelphia base for HSS's international operations, I believe this organizational connection runs deeper than physical adjacency. George Sarton's century-old charge to historians of science to reveal the truth of their subject animates the research and diverse perspectives embedded in the narratives we craft for our scientifically curious audiences across the globe.

The publication you are holding is a compendium of such narratives, a selection drawn from a year's worth of *Distillations* articles originally published on our website and that exemplify the Institute's commitment to "tell the stories behind the science." These stories feature characters and occurrences in the history of the chemical and life sciences that have too often been ignored by the public—a public immersed in the products and effects of past scientific endeavors but rarely cognizant of their origins.

We take pride and pleasure in recovering these stories and in sharing how they are connected to the scientific phenomena that shape our daily lives. Please enjoy this rich sample of our trove of stories on science's past; I invite you to visit **sciencehistory.org/stories** to discover more award-winning articles and podcasts that explore the history of science "in all its forms."

DAVID A. COLE
PRESIDENT AND CEO
SCIENCE HISTORY INSTITUTE

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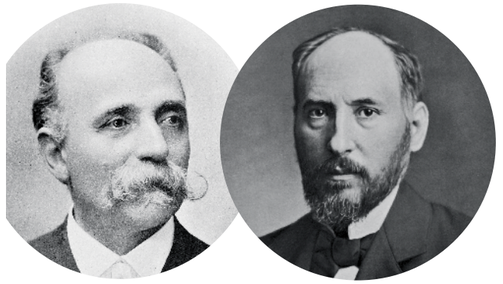
Features



Prison Plastic Surgery

Can a new look unlock a new life?

BY SAM KEAN

All she wanted was to look normal. As a young girl in Canada, a car accident had crushed her nose, and the resulting dents and scars left her horribly self-conscious. She felt she never fit in with her peers.

After a wayward youth marked by drug use, she turned to theft to support her addiction, and in the late 1950s, at 28, she was incarcerated at Oakalla Prison near Vancouver. She made the most of her time there, taking classes on typing and English grammar and entering drug counseling. But however gratifying, these services couldn't fix her main source of distress—her ugly, battered nose.

> “Even if a state paid surgeons $100,000 per operation, that seems like a bargain compared to keeping someone incarcerated.”

One day, however, the woman learned that a plastic surgeon who volunteered at Oakalla was offering to fix prisoners' faces for free. His name was Edward Lewison, and he had some unorthodox ideas. Namely, that scars and facial deformities marked people as social outcasts and drove them into crime.

Theories linking looks and criminal behavior were nothing new. A century before, an Italian doctor and eugenicist named Cesare Lombroso promoted the idea that certain facial features—jutting jaws, sloping foreheads, big ears—indelibly marked some people as criminals, partly because those features revealed a reversion to a savage, ape-like ancestor with no impulse control. Lombroso even boasted that he could pick out criminals from photographs alone.

Lombroso's theories had been debunked by the 1950s, but their influence lingered in Lewison's notion that facial defects pushed people into crime—especially defects in children. “These children, when they grow up, become weaklings in character and are unable to earn an honest living,” he wrote. Being “barred from the normal community of man,” they use crime “as their way of getting even with nature and society.” If that was true, Lewison reasoned that plastic surgery could fix the problem. By giving people a new face, he could give them a new life.

Lewison saw plenty of opportunities to test his theory at Oakalla—the prison population, he said, was rife with broken noses, scars, gnarled teeth, and bulging ears. So he began repairing these imperfections at no cost. The results impressed him. After fixing the nose of the woman in the car crash, for instance, he reported that she became much sunnier and got along better with guards. On her release from prison, she reunited with her husband and settled down to a stable life, free of drugs and crime. “She regarded the operation as a significant step towards becoming socially acceptable,” Lewison noted.

Eventually he drew up a formal scientific study about his work to determine whether plastic surgery could lower rates of recidivism and keep inmates out of trouble after their release. He published his results in 1965, reporting on 450 operations—mostly nose jobs, although he also reconstructed ears, removed scars, and rebuilt jaws. Over the course of 10 years, 42% of the surgical patients got arrested again after their release and returned to prison. In contrast, 75% of prisoners overall returned to prison—a difference of 33 percentage points. Lewison crowed: the experiment looked like a huge success.

At least on the surface. In the paper, Lewison admitted finding a small but disturbing trend. Some patients, emboldened by their new faces, left behind violent crimes such as robbery only to become scam artists. Their newly handsome faces made people trust them more, and they took full advantage.

More fundamentally, critics noticed several problems with Lewison's methodology. First, in comparing recidivism rates, he used the general prison population as a control group. But in selecting his surgical patients, Lewison chose only prisoners who had committed five crimes or fewer. In other words, he left out the prisoners who committed the most crimes and were therefore most likely to return to prison. His control group was not a valid one for comparison.

Second, Lewison didn't account for psychological factors. Many prisoners came from poor, dysfunctional homes and lacked access to medical care. Lewison's offer to fix their faces, for free, was an act of kindness in lives that had seen far too little of it. Indeed, Lewison's attention alone—showing he cared—might have motivated them to change their lives all by itself. Similarly, some patients probably felt grateful and wanted to pay the kindness forward by becoming better members of society and avoiding future crimes. Their new faces might have had nothing to do with their improved behavior.

A Surgical Operation, by Virginia Powell, 1997.

WELLCOME COLLECTION

Finally, in addition to seeking surgery, some of Lewison's patients were improving their lives in other ways. Again, the woman with the battered nose was taking classes and entered drug counseling at Oakalla. So did the surgery change her life, or did those other services? Lewison couldn't tell. Overall, these flaws seriously undermined his study, making it impossible to conclude whether plastic surgery per se helped keep people out of prison.

To address such problems, a trio of doctors began another, better-designed study in 1966. They selected 663 inmates at Sing Sing prison in New York and divided them into four groups. One group received only plastic surgery. The second received only social services such as vocational training and counseling. The third received both surgery and social services. The last received nothing at all, as a control. Within each group, the doctors also sorted the patients based on whether they had a drug addiction, for an additional variable.

Unfortunately, the results of this experiment were messy. Among prisoners with drug addictions, those receiving both surgery and social services returned to prison at a rate of 50%. Those receiving only surgery returned at a rate of 67%. Those receiving only social services were at 48%. Those who received nothing ended up back in prison at the highest rate of all.

Among prisoners with no addiction problem, those who received surgery and social services returned to prison at a rate of 33%. Those who received only surgery were at 30%. Those who received services alone were at 89%. Those who got nothing were at 56%.

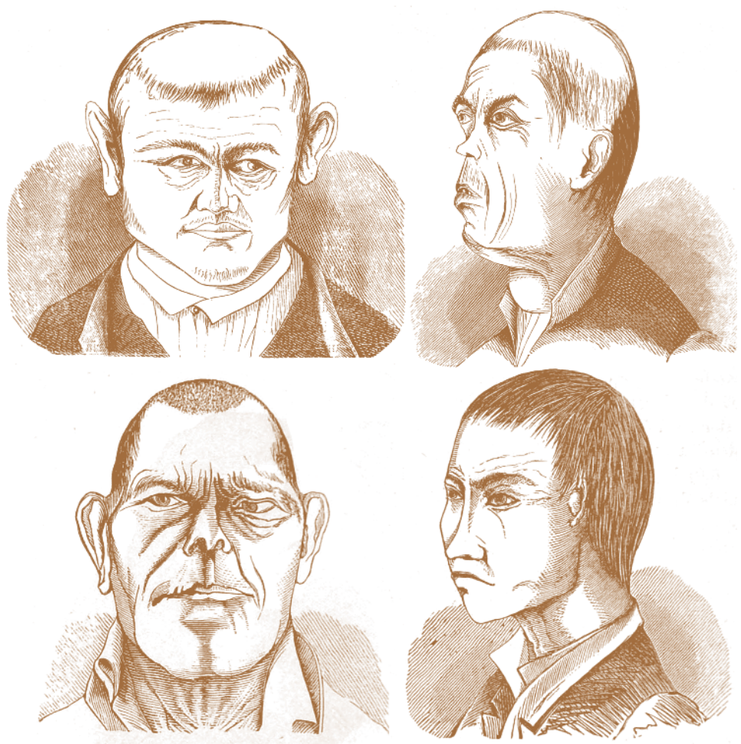
Overall, no clear trends emerge from this data. Surgery apparently did nothing for people with addictions but somehow helped the others a lot. And counseling and vocational training somehow made inmates without drug problems far more likely to wind up back in prison, which doesn't make sense.

Despite this muddle, the Vancouver and New York studies inspired a slew of others in the decades that followed—in Texas, Virginia, Illinois, England, Ontario—involving thousands more inmates. As before, the surgeons involved mostly fixed noses, ears, and teeth, but they also removed pockmarks, tightened saggy jowls, lipo-sucked love handles, and cinched up baggy eyes. Most of this work was cosmetic, but new noses also helped some prisoners breathe more easily. Understandably, these programs proved wildly popular. A few inmates even refused parole to stick around and get work done.

Enthusiasm ran high among doctors as well. One suggested that plastic surgeons should advise judges at sentencing hearings, especially with teenagers. Surgeons, he proposed, would study the faces of the newly convicted and determine who would benefit most from surgery. Those lucky few would then be sent to hospitals instead of juvenile detention centers.

Of nine studies overall, including those in Vancouver and New York, six found that plastic surgery lowered recidivism rates among prisoners. Two found no effect, and in one study, those who received surgery returned to prison at higher rates. This points to some positive, if modest, effect.

Problems continued to plague these studies, however. In an ethically dicey decision, the state of Virginia began allowing young doctors to practice surgeries on prisoners in 1970—essentially letting rookies make mistakes on a vulnerable population. The practice continued into the 1980s. Methodological issues continued as well. Some prisons used the surgeries as bribes for good behavior. But inmates who behaved well and followed rules were probably more likely to stay out of prison later anyway. Or consider inmates who enrolled in the studies and got their hopes up for surgery, only to receive social services alone—or nothing at all. The pain of yet another rejection might have driven them to lash out by reverting to crime.



In *L'uomo delinquente (The Criminal Man)*, Cesare Lombroso details facial features associated with different classes of criminals, including *(clockwise, from the top)* rapists, thieves, assassins, and bandits, 1889.

WELLCOME COLLECTION

Other critics raised points that challenge the very idea that surgery could ever help improve prisoners' outcomes. Consider a normal-looking adolescent who, for whatever reason, begins committing crimes. In doing so, he's potentially putting himself in violent situations—situations that can produce scars, broken noses, and other defects. In that case, the physical defects weren't causing the crimes, the crimes were causing the physical defects. So how would surgery help?

More fundamentally, reentering society is difficult even for those best prepared for it, and the likelihood of returning to prison depends on more than a person's individual initiative or whether they took classes or received social services. The quality of a person's support network, their length of time in prison, and their ability to find a stable job and affordable housing are just a few of the factors affecting their chance of success. In the face of these challenges, a crooked nose doesn't seem all that consequential.

Prisoner-surgery programs ran into other roadblocks in the 1970s. Prisoner rehabilitation in general was falling out of favor, as U.S. and Canadian societies shifted toward a harsher, law-and-order mentality that emphasized punishment. In addition, as word of the programs spread, everyday citizens protested. Some complained about scofflaws getting expensive surgeries for free while law-abiding citizens paid through the nose. Others made moral objections. They saw self-improvement as a function of discipline, hard work, and even suffering. To this mindset, taking a shortcut to goodness, like plastic surgery, was akin to cheating.

Given the methodological problems and wider societal changes, prisoner plastic-surgery programs ceased in the 1980s. Surprisingly, however, the pendulum has recently started swinging back in their direction, for a few reasons.

One is the so-called beauty premium. In short, a robust body of evidence from psychological research shows that being good-looking really does give people a big boost in life. This boost starts young. Handsome schoolchildren receive more attention from teachers and are perceived as smarter and more popular. After graduation, the beautiful ones earn higher salaries and garner more tips, among other benefits.

The beauty premium influences the criminal justice system, too. Attractive folks are less likely to be arrested. They get fined less for minor offenses and receive shorter prison sentences for big ones. They also have an easier time finding jobs after prison. All of which seems to support Edward Lewison's theories. Give people a new, attractive face, and they should have an easier time in life and stay out of trouble with the law.

Prisons are also, especially in the United States, facing a crisis. The law-and-order mentality of the 1970s has given the United States the highest incarceration rate in the world. As a result, prisons are overcrowded and don't prepare people to reenter society. Prisons are also growing expensive. In New York City, it costs roughly $560,000—every year—to house an inmate.

Given those problems, and reality of the beauty premium, people are giving Lewison's ideas another chance. Nonprofits have sprung up in Hawaii, Arizona, and California to help former prisoners fix their faces and receive other services such as tattoo removal. There's a fiscal case for rehabilitating Lewison's ideas as well. Even if a state paid surgeons $100,000 per operation, that seems like a bargain compared to keeping someone incarcerated.

We many never know for sure whether Lewison was right that making someone more beautiful can transform their inner life, too. But inside prison or out, we can't escape the power and lure of beauty. D

Sam Kean is a best-selling science author. His latest book is The Icepick Surgeon: Murder, Fraud, Sabotage, Piracy, and Other Dastardly Deeds Perpetrated in the Name of Science.

Forests of the Future

Modern agricultural practices are unsustainable. Is tree farming the answer?

BY KATE MORGAN

"Don't step on my babies," Buzz Ferver orders, more than once. His loafers have all but disappeared into a dense carpet of dandelions, making it difficult to walk in his footsteps, as instructed.

On his Perfect Circle Farm in the shadow of Vermont's craggy Worcester Range, Ferver picks his way through rows of small trees. He inspects grafts—the places where he's sliced open the bark of a rooted sapling and fused it with a cutting from the tree he wants to clone—and straightens the long sticks he ties to each young trunk to keep birds from perching on the delicate new growth. Raised in the Delaware Valley outside Philadelphia, Ferver relocated to Vermont in 2004 and bought this farm in 2015. In the intervening years, he estimates he's "killed untold thousands" of seedlings while attempting to produce hardy trees in the New England climate. To the untrained eye, Perfect Circle is a typical, if especially idyllic, tree and plant nursery. But as he carefully prunes a yearling hican tree, Ferver announces his greater mission: "I am building an ark."

The hican is a remarkable, unlikely thing. It's a hybrid of pecan and hickory, both members of the *Carya* genus and close enough relatives that occasionally, when the conditions are just right, cross-pollination can occur. What results is a towering, rough-barked tree, thick with foliage, that produces a sweet, palm-sized nut.

In Ferver's field, spindly hican seedlings bear labels with their ancestral name: "McAllister—Hershey." They're descendants of a massive hican, 100 feet tall and nearly as wide, planted a century ago by a legendary Pennsylvania nurseryman named John W. Hershey. That tree is dead now, cut down in 2019 to make way for an apartment complex. But Ferver has devoted his life to preserving Hershey's McAllister hican and a huge variety of other nut and fruit tree species. He's part of a group of hopeful dendrophiles who believe the farms of the future will forgo neat rows of crops baking under the hot sun.

Instead, they've embraced food forests: wooded plots that feed livestock and people alike, all of it anchored by nut trees. Ferver and his ilk are determined to preserve the genetics and provenance of the best pecans, chestnuts, hickories, hazelnuts, walnuts, butternuts, heartnuts, oaks, honey locusts, persimmons, paw paws, plums, pears, mulberries, and more—the cultivars that will feed the future. That's the "ark" he's talking about. "I'm trying to leave behind a germplasm that, from a climate perspective, from an ecological perspective, and from a human survival perspective, we're going to need," he says.

Agriculture, as we imagine it, is a relatively recent invention in North America. While the earliest European colonists farmed at a subsistence scale, a mid-18th-century population boom in Europe created a thriving international cereals market, and American farmers responded by clearing huge acreages of hardwood forest to plant wheat and corn. The introduction of the cotton gin and a growing global textile trade fueled the expansion of Southern plantations.

Throughout the 19th century, pioneers poured over the Appalachian Mountains to claim tracts of land issued by the federal government or purchased from the rapidly expanding railroad. Immigrant European farmers descended on the American prairie and planted ever more wheat fields, while the Great Plains, now devoid of the massive, migrating bison herds of yore, became pastureland for countless cattle operations. Mechanization of farming equipment after World War I allowed for even more expansion, and our industrialized food production system was born.

But that system is unsustainable. The United Nations calls industrial farming "fundamentally at odds with environmental health." In 2020, according to EPA estimates, the nation's agricultural operations emitted more than 11% of the nation's total greenhouse gas emissions.

Chemical fertilizers, pesticides, antibiotics, and growth hormones used to increase yields are also a proven risk to human health. And just as agriculture contributes to climate change, the changing climate has a direct impact on farming. It's clear, says Ferver, that agriculture will face a reckoning.

"At some point, we may want to replace 200 million acres of corn with something that has high food value, sequesters carbon, and will live for 100 years," he says. Nut trees could be part of the solution.

Before colonial settlement, the Atlantic Coast was one of Earth's richest biomes: a great, dense forest of hardwood trees that spread from Maine to the Gulf Coast, and west past the Mississippi River. Indigenous people farmed that forest, selecting for the best-producing trees with the sweetest nuts and highest disease and pest resistance. Their efforts culminated in a dependable crop of food high in oils, carbohydrates, and protein that fed people, livestock, and wild game.

So, agroforestry—a system that integrates pasture, ground crops, and shrubs beneath a tree canopy—isn't a new concept, though the term was coined as recently as the 1970s. Decades earlier, in 1929, University of Pennsylvania geographer J. Russell Smith published *Tree Crops: A Permanent Agriculture*, in which he advocated for a return to that kind of sustainable, ecosystem-supporting tree crop production. Today he's commonly referred to as the father of agroforestry, and he instilled its tenets in his young protégé, John W. Hershey.

Spring Farm Work—Grafting, engraving from an illustration by Winslow Homer, *Harper's Weekly*, April 1870.

Hershey was in his early 20s in 1921 when he opened a small nursery in Downingtown, Pennsylvania, less than an hour's drive from Philadelphia. He sold his trees locally and published catalogs and pamphlets that encouraged soil maintenance and regenerative farming practices with roots in Indigenous techniques.

In the early 1930s President Franklin Roosevelt created the Tennessee Valley Authority (TVA) to help revive a region hit hard by the Great Depression. As part of the initiative's environmental and agricultural goals—including preventing a Southern version of the Dust Bowl that was pummeling the American prairie—a tree crops division was established. When the division's chairman asked Smith to suggest a man to lead the operation on the ground, he called on Hershey. Though Hershey had no formal forestry degree, the young Quaker saw the job as a spiritual and patriotic calling. "It is more important to save this country by growing trees and preserving the soil, than it is to try to save it by sending men to war," he would later write in a self-published book.

Hershey ran TVA-sponsored contests, advertising in local newspapers and encouraging farmers in the valley to send in material from their best trees for cash prizes. "Hershey's tree-crops section in the TVA offered prizes for the best acorns, the best honey-locust pods, the best persimmons, the best blueberries, and other wild fruits," wrote Smith in a 1953 edition of *Tree Crops*. The winners came from old trees on Southern farms, many of them almost certainly the work of Indigenous forest farmers.

Hershey's TVA nursery flourished, and the best seedlings and grafted young trees were grown and propagated, their progeny distributed to farms across the valley. In 1939, Hershey returned to Downingtown and brought the genetics of those carefully bred cultivars with him. By 1945, he had expanded to 75 acres. It was a treasure trove, "America's No. 1 Tree Crop Farm," according to Smith.

Hershey believed it would be the wellspring for a wider reforesting movement. A farmer far ahead of his time, he evangelized about organic gardening practices and soil health, water retention, cover crops, and rotational grazing. He foresaw a return to a kind of agriculture that would feed people, livestock, and game alike and produce timber and other income sources for farmers. On his plot in Downingtown, the vision came to life.

Hershey's livestock grazed beneath the trees. Fat honey locust pods fed horses and cows, and when the chestnuts dropped their spiky burrs, the steers ate the sweet nuts inside. Persimmon and mulberry trees stained the ground with their fruit, a veritable feast for Hershey's pigs. In autumn, the farm was a palette of red, orange, and yellow, and each spring, thick new growth wove a lush green roof over this burgeoning paradise.

The experiment was repeated by other legendary nurserymen who followed Hershey. Speak to anyone in the informal northeastern nut tree network, and you'll hear the same names repeated again and again: Archie "Mr. Black Walnut" Sparks; John Gordon, an eccentric grower of uncommon cultivars; American chestnut devotee Arthur Graves.

METROPOLITAN MUSEUM OF ART

After a career as an oilman, James Claypool retired to his Illinois hometown and spent the next 25 years as the world's foremost breeder of persimmons. Fayette Etter was a telephone lineman who hunted for the best wild hickories along his service route to use in grafting and crossbreeding experiments. Sometime in the 1950s or 1960s, Etter ended up in a courtroom in Franklin County, Pennsylvania, arguing against a planned bridge-improvement project that would require cutting down a shagbark hickory tree he had dubbed the "Keystone." As the story goes, Etter gave the judge a hickory nut to crack. Declaring it "the finest nut I've ever seen," the judge ordered the bridge relocated further downstream. A flood the following year took out both the new bridge and the tree, but not before it had been grafted and cloned. On his farm in Gettysburg, Pennsylvania, Parker Coble, a local teacher sometimes affectionately called "the Nutty Professor," grew English walnuts the size of a tennis ball and established one of the nation's biggest plantings of butternut trees.

But of all the many celebrated names and reputations in the world of nut growers, none looms quite so large as Hershey's, even though he spent much of his career working in a diminished health capacity after a cancer diagnosis in 1936.

In the 1960s, with the illness advancing, Hershey began laying plans for the future. He proposed that the Brandywine Valley Association, the nation's first small watershed alliance, acquire the property and preserve it as an arboretum. In the end, the association decided to use the funds for other projects. Hershey died in 1967. "The tree crop farm had to be sold. The nursery closed down. Dreams sometimes end like this," his wife, Elizabeth, wrote. The land was parceled out and developed. Today, Downingtown is a busy suburb of shopping centers, retirement homes, and townhouses. But many of the trees are still there, if you know where to look.

Although rarely marketed as such, a nut is technically a dry, single-seeded fruit. Some, like acorns, chestnuts, and hazelnuts, are considered "true nuts": they contain both a tree's amalgamated fruit and seed, and they're indehiscent, meaning the hard, inedible shell or hull doesn't split open when ripe. Others, like almonds and cashews, have a fleshy outer fruit around a seed, which is the part we eat. These fall into a category called drupes, though the USDA nonetheless classifies them as nuts.

Across species, nuts are chemically constructed of proteins and lipids and are rich in health-supporting compounds, including unsaturated fats; fiber; vitamins; phytosterols, which can help lower cholesterol; and phenolic compounds, which work as antioxidants. In studies, nut consumption has been shown to lower blood pressure and is associated with a decreased risk of coronary heart disease, diabetes, hypertension, and cancers.

Nuts are well-suited to long-term storage and lend themselves handily to an array of preparations: raw, roasted, or ground into flour. Even a small acreage of nut trees can be a significant food source. A single healthy walnut tree can produce more than 300 pounds of nuts in a good season. The mast of a one-acre orchard of mature pecans can weigh as much as a ton. Many nut tree species alternate years of big production, but they're reliable; they can produce for 50 years, or, in many cases, much longer.

Calorically, that's a huge amount of food. According to the USDA, walnuts provide 730 kcals per 100 grams (or roughly 3.5 ounces), double the energy in the same amount of corn and considerably more than both soy and wheat. The comparison is similar between traditional crops and pecans, hazelnuts, and many other nut varieties.

Because nut trees cross-pollinate, there are endless genetic combinations within each variety (and sometimes, as in the case of the hican, across varieties). That also means seedlings can vary widely from the parent plant and makes it difficult to grow dependable producers from seed. The solution is to simply clone the parent tree by grafting. In Downingtown, the hidden-in-plain-sight remnants of Hershey's farm are a master class in successful grafts and superior cultivars.

"There's a triple-grafted walnut outside this preschool, and a whole grove of hickories and chestnuts and persimmons inside this apartment complex," says Max Paschall. An arborist and gardener at the University of Pennsylvania in Philadelphia, Paschall possesses an exuberance that makes his passion for Hershey's trees obvious. "You're looking at a persimmon, then you realize, 'that's a honey locust and, oh, that's a white oak.' You realize you're surrounded by food-producing trees," says Paschall. In a Philadelphia suburb, he contends, this is as close as you can get to "waking up in the Garden of Eden."

Though Hershey's name has been well known among nut growers, the existence of his surviving trees went largely unnoticed for decades. It's thanks to Paschall that they were, in effect, rediscovered. In 2015 he read an article about Hershey in "some obscure permaculture publication." He drove to Downingtown and was stunned by what he saw. Later that year, at a meeting of the Backyard Fruit Growers, a local enthusiasts' group, Paschall told fellow tree aficionados about what he found. Soon, a loose group of Hershey preservationists had formed and began taking regular trips to Downingtown to collect nuts and scion wood—the cuttings used to clone a tree by grafting. In the years since, the group has fought to save a number of Hershey's most iconic trees as suburban development grew. Some battles were won. Most, such as the struggle to save the massive McAllister hican, were not.

It's not just their history that makes the trees special. For the most part, they're the clones and direct descendants of trees that thrived in the south, in the kind of climatic conditions anticipated to spread across northern states in coming decades. The USDA maintains a "hardiness map," which divides the United States into growing zones based on annual minimum temperature. The map is a guide to help growers know when to plant and what is likely to thrive in each zone. In the map's 2012 update, all the lines shifted north, moving much of the country warmer by half a zone from 1990, when the map was previously updated. In 2018, researchers at the University of Idaho examined how hardiness zones would shift as a result of climate change. They predicted the map's lines will move north at a "climate velocity" of 21.4 km per decade.

The progenitors of Hershey's trees were thriving in southern hardiness zones when he collected their genetic material. The resulting plantings have withstood Pennsylvania frosts for the better part of a century and survived that long with largely no maintenance—no one to spray, prune, or fertilize. And yet they go on producing, year after year. In other words: they may be the closest we can get to a "future-proof" crop.

> Converting industrial farms to forests won't happen overnight. It won't happen in any kind of hurry at all.

"If we're looking for trees that can survive massive heat waves, or a climate where a third of the year is over 100 degrees, or there's drought, or there's frost . . . these trees have proven their mettle," says Paschall. "When I hear people worrying about our future ability to feed ourselves . . . we don't need a biotech solution or some new machine. We have a collection of trees in a suburb of Philadelphia."

Converting industrial farms to forests won't happen overnight. It won't happen in any kind of hurry at all: major cultural and commercial forces are resistant to such a major shift in farming practices, and even if landowners do jump right on board, most nut trees take several decades to begin producing. But silvopasture, an agroforestry practice that involves strategically planting trees to improve existing grazing pasture, may provide a bridge.

There are more than 650 million acres of cow pasture in the United States—the largest single use of land in the country. For Austin Unruh, it's land of opportunity. He heads up Trees for Graziers, an organization that works directly with landowners to strategically plant trees in their pastures. Choose the right trees, Unruh says, and the merits multiply. He often plants honey locusts and persimmons, which provide shade and a source of fodder that drops in the colder months, keeping feed bills low while adding energy to livestock diets.

In the last two years, Trees for Graziers has created around 400 acres of silvopasture on 30 farms, planting a total of nearly 25,000 trees. The honey locusts they use, which produce foot-long pods loaded with sweet goo, are a tree selectively bred by Hershey. The persimmons, too, are Hershey varieties, borne from trees in Downingtown. Each one that ends up in a pasture makes an impact, says Unruh, on people and the planet.

Silvopasture and other agroforestry practices do more than provide shade and an alternate fodder source. Adding trees can make *all* the food more nutritious. They create habitat for animals, including pollinators, small herbivores, and predators of both. Animal biodiversity contributes to plant biodiversity, and cycles begin to form. The soil gets healthier and so does everything that grows in it, says Robbie Coville, ecosystem products and markets specialist with the Pennsylvania Department of Conservation and Natural Resources' Bureau of Forestry. More informally, Coville is the state's new agroforester: his job is to create and expand markets for forest products, including nuts, and improve forest management on public and private land.

"Big things start to happen with any kind of shift toward the perennial," says Coville. "Soil health is going to improve a lot based on the soil food web improving." The undisturbed ground around trees has an increased number of microorganisms, he explains, which provides for a bigger community of insects and ultimately makes the soil more nutrient-dense. Water also behaves differently on silvopasture, where deeper root systems prevent erosion and increase infiltration, ensuring that rainwater moves through the soil rather than running off into gullies and ditches and carrying away topsoil with it.

Photo of John Hershey from a *Pittsburgh Post-Gazette* article in which he advocates using trees as flood control. "Flood planning don't amount to two whoops and a hurrah," he told the *Post-Gazette* in December 1950. "What you need is to plant crop trees in the watershed."

PITTSBURGH POST-GAZETTE

"Storing carbon is the big piece," says Coville. Project Drawdown, a climate-solutions nonprofit, estimates that pastures with more than 30% tree cover can capture and store as much as 10 times more carbon than treeless expanses of grass the same size. Based on data from eight different studies, the group claims each acre of silvopasture can sequester six metric tons of atmospheric carbon per year, nearly the equivalent of five cars' annual emissions.

While the long-term benefits of agroforestry are an easy sell to farmers, the initial investment is not, says Unruh. Growing trees isn't a quick business, and many landowners are still wary. Trees for Graziers is working to allay those concerns. The group helps farmers secure funding to subsidize silvopasture plantings.

"We're seeing a much bigger federal investment in regenerative agriculture and climate-smart forestry," says Coville. "That definitely extends to agroforestry. What I think we're also seeing play out here in Pennsylvania is more investment from philanthropic foundations and from private-sector investors."

Ultimately, agroforestry's advocates believe it will emerge as the most reasonable solution to agriculture's mounting challenges. As the population grows and farm acreage is converted to urban landscape and development, there's a need to grow more food on less land.

A few hundred new acres of silvopasture may be a drop in a very large bucket, but every farmer willing to plant trees on even a single acre is taking a step in the right direction, says Ferver. And that's how momentum builds. "You don't need everybody," he says. "You don't need a majority. You need between five and ten percent of the people to say, 'We've got to do this.'"

Forests play a crucial role as carbon sinks, but reforestation alone isn't enough to reverse climate change and faces skepticism on numerous fronts. Trees take years to grow and sequester carbon, but sequestered carbon is released into the atmosphere in the event of a wildfire. Even where reforestation is successful, the trees themselves can worsen wildfire potential and water-use issues in drought-prone areas.

Nut tree farming is likely to face many of the same challenges, but, done correctly, it could offer more solutions than problems. Mature trees are drought-tolerant, and older deciduous trees, such as well-established nut producers, are far less likely to burn than the faster-growing coniferous species often planted densely for the sole purpose of carbon sequestration. Much of the work involved in breeding hardy, disease-resistant tree varieties has already been done, assuming those cultivars can be preserved.

"Estate planning and farm succession is a big challenge," says Coville. In many cases, when older farmers retire or die, their children are unable or unwilling to keep the farm going. It's an issue that promises to accelerate in the coming decades. Climate change can be difficult to grasp because it requires thinking on a geologic timescale. The benefits of nut tree farming, which require thinking on a generational timescale, can be similarly difficult to make clear to a layperson—never mind local real estate and business interests. In Downingtown, the remains of Hershey's farm are a cautionary tale. "He had the intention of putting a succession plan in place so his farm would be transferred into something like a trust, but he wasn't able to do the necessary estate planning in time," says Coville. "Now we can walk around his past nursery and see the outcome: a lot of subdivision and development."

The pioneers of nut tree farming are all gone now, and the legendary growers who are still left are in their 80s and 90s. "They are not going to last forever, and what they have is really valuable," says Louise Bugbee, a biologist in eastern Pennsylvania's Northampton County who runs a private environmental consulting firm. "But unless someone is able to . . . take care of those trees, then they're going to be gone just like Hershey's. What we've seen is that when the trees outlive their growers, a lot of times the family sells the farm, they sell the orchard, the land gets divided up, the kids need the money, and the trees are lost to us."

When Bugbee learned about Hershey's former farm and the precariousness of the remaining trees, she became determined to give them a new home.

"I just thought, my God, we have to save what's left. We need a place where these trees can grow and be documented so that we know where they are. A place where, in the future, we can be sure that people will be able to come and collect those nuts and get that scion wood to continue propagating these trees. A place with enough room so that the trees can cross-pollinate at will and hybridize, do their own thing and maybe make that next best nut."

In a 100-acre public park just off the Lehigh Valley Thruway, Bugbee's building her own ark. Nearly five dozen tiny trees, grafted by Ferver and wrapped in mesh cages to keep them safe from being trampled or eaten by deer, dot a gently sloping hillside. She plans to add more—a lot more—including cultivars "that are being developed now by growers like Buzz and others like him." Even if some of the old-timers' farms do slip away, Bugbee plans to keep the trees (or, at least, clones of the trees) going strong.

"It's a public space that I knew we could maintain for 100 years," she says. "A place that would have public access; where we have institutional memory and where we know someone's always going to be there to care for them; where we have a secure building to keep the records of what we have, where it came from, and why it's important."

Nut trees and nurserymen don't live forever. But good grafts take, and there's always time to try something new. That, Bugbee says, is the wisdom of an old nut grower. "The beauty of these guys is they're like 90 years old, and they're grafting trees and they can't wait to see what they're going to get," she says. It's a poignant lesson in planting a tree you'll never enjoy the shade of. In Northampton County, Bugbee says that's exactly what she's doing.

"When I give tours, I have to explain what this is not for," she says. "It's not for me, it's not for you. It's not for us. This is for people in the future. I take them out and I make them stand there. You have to have an imagination for this. You have to imagine that tree in 10 years, in 50 years, in 80 years. You have to imagine that big expanse of field with 10 gigantic trees in it, and they're all dropping nuts."

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Fish Hacks

Often dismissed as a "trash fish," the porgy anchors black maritime culture.

BY JAYSON MAURICE PORTER

John Scott (poppy), ca. 1950s.

John Scott is the kind of man who prefers to catch and clean his own fish. My nana calls him a street person, especially when annoyed with him. However, this irritation cannot hide her smirk and cute eye roll of reluctant approval: that's her street person. Ever since retiring from his dual careers as an army-trained welder and a Muslim minister, my poppy has worked outside. If he can use his hands to make or save money, he will. The more informal and messier the work is, the better. He melts coins into gaudy jewelry and trims down short-brimmed hats from long-brimmed ones.

While my poppy could still walk and drive the streets, he hacked, driving people home from ShopRite and other grocery stores in and around Germantown, Philadelphia. This was when Philly was black on all sides. Before Uber and Lyft and before the police labeled hacks "illegal taxis"; before gentrification altered how black people could support one another. Before COVID-19, a street person like my poppy could drive you home with your groceries and even sell you freshly caught and cleaned porgies (*Stenotomus chrysops*) on the way. Some people call this fish scup, menhaden, or sea bream, but in Germantown in the early 2000s, one might have still heard "porgies for sale" echoing in the parking lot.

The porgy is no prize fish. Commercial fishermen and chefs often label them "bycatch" or "trash fish" because they are so easily caught in the wild that anyone could do it by accident. But, ironically, not everyone can prepare porgy. Cleaning and eating them at home takes patience. Each fish has about as many bones as the species has breeding grounds along the Mid-Atlantic Bight from Massachusetts to North Carolina. Maybe the species' abundance and boniness convinced the Narragansett and Abenaki people to scatter porgies on agricultural plots as a fertilizer. One source actually insists that the word porgy comes from Abenaki words for fertilizer, *pookagan* and *poghaden*. However, other records suggest that the terms scup and porgy are colonial reductions of the Narragansett word *scuppaug*. For John Scott, porgies mean everything.

My poppy loves his porgies coated in cornmeal, panfried, and served with two condiments: sliced white bread and hot sauce. He eats his fillets carefully while listening to something on the Discovery Channel or *Entertainment Tonight*. After removing the most visible bones with a fork, his tongue rubs the insides of his lips and cheeks to double-check before any chewing happens. Cleaning and then eating around these tiny, translucent bones takes skill. Scarf down a porgy fillet too quickly, and a bone will remind you to slow down. Its flaky texture profile might resemble snapper, but it has far too many bones for salad, sushi, and inattention. Chefs in the northeast historically considered porgies too commonplace and industrial for restaurants, but watching my poppy eat one with his mouth open to spit out bones makes you think maybe it's a fish best eaten in private.

Eating porgies at home is a global pastime. People fish over 150 species in the porgy family (*Sparidae*) in temperate and tropical waters worldwide. Each species varies in size and color, but *Sparidae* shares many features: singular dorsal fins, shallow-water habitats, and small mouths with strong, molar-like teeth for eating hard-shelled invertebrates.

Their affinity for eating crab and mussels gives the porgy family their distinctive sweet and shrimplike taste. The South African black musselcracker (*Cymatoceps nasutus*) is a popular sporting fish that can reach over 100 pounds in weight. But most *Sparidae*, like the *Stenotomus chrysops* that my poppy catches, do not exceed a foot in length or a pound in weight.

The Three Strikes You're Out fishing crew posing with a tall tale in the making.

COURTESY SANDRA MCCALL

COURTESY DELORES SCOTT

These smaller varieties have many colloquial names because so many people eat them. Japanese fishermen call them *tai*. Settlers in Australia and New Zealand tend to call their porgies *snapper*, following a tradition of colonial misidentification that goes back to Captain Cook in 1770. But since this porgy (*Chrysophrys auratus*) inhabits coastal waters from the Philippines to Indonesia, it likely has countless Indigenous names. To paraphrase my nana, Māori people have used the word *tamure* since before Captain Cook was born. Maybe even as long as the Dharug people of Southeast Australia have referred to them as *wollamie*.

Nineteenth-century industries tried to fasten even more names to porgies. Machines broke *Stenotomus chrysops* down into oil, bones, and scraps to make lantern oil, soap, and fertilizer. New England settlers built entire fisheries, with porgy steamers and porgy factories, to make porgy products. Since the days of salting porgies and sending them to Caribbean plantations to feed enslaved labor, northeastern fisheries have imagined great wealth in drying porgies.

Building on Indigenous methods of using porgy for fertilizer, the Quinnipiac Fertilizer Company secured a patent in 1852 for drying fish scrap by solar heat, and used this technique to produce enough fertilizers for plantation owners in New England, southern states, and the Caribbean. Soon, the Pacific Guano Company of Boston started using dried porgy to supplement dwindling bird guano supplies and meet increasing demands for fertilizers. After the abolition of slavery, southern cotton planters adopted these chemical solutions to replace enslaved labor, and the Boston company found great success mixing dried porgy with phosphates from South Carolina.

But not for long. Fisheries, big and small, never fully understood or controlled porgy behavior. Porgies' sexuality does not map well on spreadsheets, table graphs, and economic forecasting. Many porgy specimens carry male and female organs simultaneously; others change sex as they mature. Their breeding tendencies often didn't look like tendencies. Some years waters overflowed with the fish, but then they could disappear for decades at a time. Rachel Carson wrote that porgy became one of the most important industrial fish, especially for fertilizers, but with a history marked by "severe fluctuations in the catch."

Big companies could outlast this uncertainty, but most fishermen went bankrupt betting on porgies. According to the leading contemporary scientific journals, thousands of black fishermen also made careers in fisheries in the 1870s and 1880s. Numbers decreased drastically by the 1890s. The professionalization of the industry excluded them. Black-operated fisheries likely also struggled to weather porgy droughts, but records do not tell their full story. Black fishing people, especially those outside of formal fisheries, were as illegible to the industry as porgies. On black fishing, journals usually quoted the Smithsonian Institute's foremost expert on fisheries, George Brown Goode, who admitted that "the negro element in the fishing population is somewhat extensive. We have no means of ascertaining how many of this race are included among the native-born Americans returned by the census reporters."

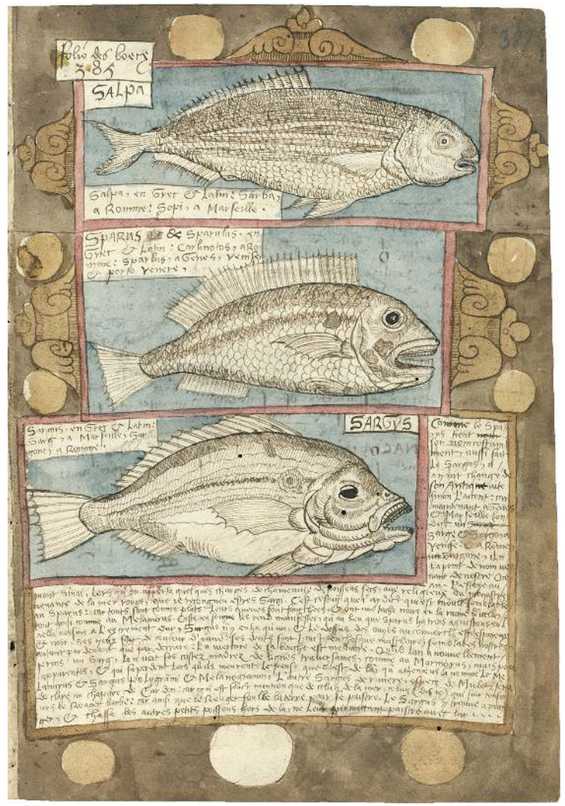
Novelist DuBose Heyward actually knew black fisherman from growing up in Charleston. In 1925, the year before my poppy was born in Alabama, Heyward published *Porgy*. It describes how black fishermen discharged "strings of gleaming whiting and porgy" and how black stevedores loaded boats. It remembers black folks living near the Boston company's fertilizer mills where they worked and how they "stank intolerably," and how others worked in nearby phosphate mines after cotton season. *Porgy* also offers readers a glimpse into the picnic and parade culture of black folks in Lowcountry South Carolina. Heyward illustrates places where the "earth had cared for" us; where the creeks shared fish, crabs, and oysters and the forests had berries and palmetto cabbage. Fishermen were not central to this story of black recreation, but Heyward's novel does underscore the centrality of rivers and oceans to black senses of freedom. Without even highlighting *Sparidae* fishes, *Porgy* helps us imagine the liberatory role of porgies across the African diaspora in the Americas.

From the Gulf of Mexico to Colombia, coastal black and Indigenous communities have fished varieties of porgies for centuries. Like their relatives in the Pacific, some red porgies (*Pagrus pagrus*) in tropical American waters have a "snapper" problem that goes back to the colonial period. Other types of *Pagrus* are common in West African waters and might have even provided enslaved African people in the Caribbean Basin with a rare sense of familiarity. In any case, porgies were likely vital food sources for black peasant and fishing communities in the wake of slavery.

Red snapper (*Lutjanus campechanus*) gets all the attention, but look closely at Haitian, Jamaican, and Cuban cookbooks, and you will see dishes designed for porgies. Consider this: if white settlers historically considered oysters, clams, and mussels poor-quality foods for black and Indigenous consumption, then shellfish-eating porgies that inhabited the shellfish ecosystems were some of the most accessible fish to black and Indigenous communities.

The abundance and catchability of porgies add to their accessibility. Porgies do not swim into deep waters or stray too far from the continental shelf. They avoid traveling too far from their prey, concentrated in coastal reefs and bays, shallow seafloors, rocky outcrops, and mussel beds. Porgies seldom move in solitude but prefer migrating in loose, multispecies schools of similar-size fishes. Finally, porgies generally lack finesse. They do not nibble gently at the bait but instead attack it frantically and forcefully as if it were a mussel fastened to a rock with its mollusk foot. Use tough and rubbery bait like squid strips, and it won't take long for a porgy to try to yank it off. If the temperature and location are right, my poppy does not need more than a few hours to catch 50 porgies.

Page from Dutch fisherman Adriaen Coenen's Vis *booc* (Fish Book) describing different varieties of porgy, 1577–1579.



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John Scott fell in love with the ocean when he moved from Alabama to Atlantic City during the Great Depression. He does not remember selling ice cream as a teenager on the boardwalk as a chore. He heard and saw the ocean all day. He tasted the ocean, too. This appreciation of fresh seafood continued when he relocated to Philadelphia to work as a welder after World War II. If anything, his love for fresh fish only grew stronger after he converted to Islam and stopped eating pork. Bless my nana because my poppy is a generational talent at picky eating. He's the kind of military man turned minister who shaves daily, cuts his hair every three days, and always takes an hour to get dressed. He would not hesitate to whine about lousy fish. To avoid him complaining about the quality of fish, my nana probably agreed to cook only what he bought or caught himself. He was a regular at the big fish markets in South Philly, but after retirement, he preferred to fish with his friends.

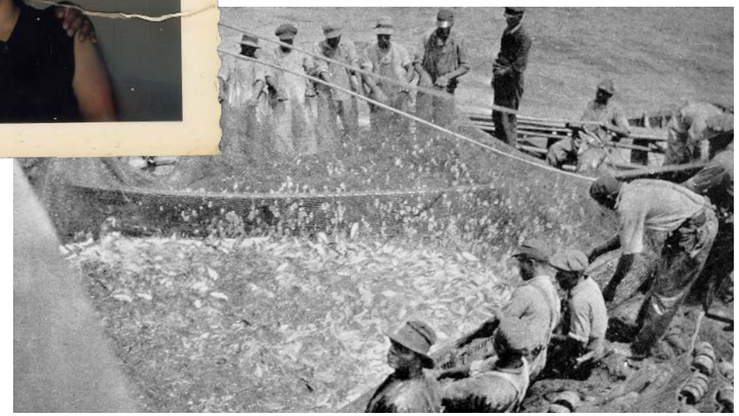
For black folks, staying connected to the ocean is often a community affair. In the 1970s black-owned fish trucks sold residents in North and West Philly fresh porgies and other fish. In 2018 ecologist Talia Young started a community-supported fishery called Fishadelphia to provide fresh fish from local fisheries to "culturally and economically diverse seafood eaters." They buy what's available on the docks to offer members seafood tied to their own traditions. My poppy operated at a much smaller scale from the 1980s to the 2010s and organized short fishing trips to Cape Cod with a group of elderly black men called Three Strikes You're Out. Commitment to each other was paramount. Their goal was not necessarily economic. They did not see their effort as social justice. These frugal older men just wanted to fish and sell enough porgies to pay their way.

My annual summer visits to Philadelphia coincided with these fishing trips and the return of *Stenotomus chrysops* to coastal waters. After wintering along the mid and outer continental shelf, adult porgies form schools with various, similar-sized species in the spring and migrate inshore. The ritual for my poppy's return to the ocean with his kindred spirits goes as follows: select a date, pack the coolers with ice, pick up Dunkin' Donuts, and meet at the charter bus before midnight. Once at the bus, this pack of 20 or so retired black men and their progeny load the bus with coolers and fishing rods and begin to make their way to Cape Cod.

The sound of seagulls signals our arrival. It's hardly 6:00 a.m., but it's bright and light blue on the pier. From there, things move quickly. Each poppy finds his favorite spot on the boat, sets up his station, and prepares his bait as the captain embarks for deeper waters. But not too deep. The goal is to find a shallow feeding ground inhabited by mussels, sand dollars, and schools of porgy. The vast seascape looks just like flat water to me, but the captain combines his radar and memory to envision a whole world underneath us. The boat picks up speed and moisture. The air feels hurried and is sprinkled with crusty salty water.

From left, Delores Scott (nana), John Scott, and his sister Johnnie Mae, ca. 1960s.

Fishers pulling in a purse seine net of menhaden, from a report to the U.S. Department of Commerce by scientist Lewis Radcliffe, 1921.



COURTESY SANDRA MCCALL; BIODIVERSITY HERITAGE LIBRARY

Then the boat shakes to a stop, and the air goes still and quiet. Without the ship engine rumbling, you can hear the few seagulls that followed the boat signal our arrival again. Fishing starts around 6:30 or 7:00.

The narrow deck that wraps around the boat gets bloody and slick. The first fishing lines cast catch porgies within seconds, and a veritable fish frenzy erupts within minutes.

Porgy fishing is all drama, no suspense. The fish are aggressive anglers that bite recklessly at bait with little strategy or ruse. We pulled up so many fish in two hours that one might think the schools of fish were visible in the water. But they weren't. Look out across the water—you'd think we were in the middle of the ocean. Only seagulls' calls and fish flip-flopping in buckets give you a sense of the biodiverse feeding grounds below the boat. Catching the occasional flounder is another reminder of this shallow-water habitat. The captain might relocate the boat to three or four feeding grounds depending on the weather and water temperature. But one or two can provide enough porgies to fill all coolers. Fishing ends around 10:00 or 10:30.

Most of the ride back to the pier and then back to Philly is just older men bragging about whose grandson or nephew caught the most porgies. During our long stretch home, my 20-porgy haul became a story about me catching 40 porgies. My poppy was so happy to lie and say he caught no fish at all.

At home, he wastes no time cleaning our 40 or so fish. Porgy is a particularly smelly species, and cleaning any fish is messy, so this is an exclusively back-porch activity. And it can be tricky on a late afternoon in Philly during the summer. Without letting the fish drop below 40 degrees, my poppy rinses and descales each fish. Scales fly everywhere. Some stick to his forearms and add glisten to the jewelry he made from coins. He removes their guts, gills, and heads, then places the fillets in bags and back on ice. If he was lucky, he found some fish eggs to save for my nana, who insists he (her street person) cleans porgies just like his mother cleaned porgies. With the freezer filled with enough fish to last a month, my poppy repacks his cooler with most of the remaining fish. He leaves a few fillets for us to eat for dinner and then heads to ShopRite to sell the rest. D

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A Cold Day in Stockholm

At the dawn of a new age in neuroscience, the rivalry between Camillo Golgi and Santiago Ramón y Cajal reached an icy climax.

BEN SEAL

CAJAL INSTITUTE, SPANISH NATIONAL RESEARCH COUNCIL

Microphotograph of pyramidal neurons by Santiago Ramón y Cajal.

Camillo Golgi couldn't stop thinking about Santiago Ramón y Cajal. As the wan December sun began to rise on icy Stockholm, his mind turned again to his extroverted Spanish antagonist. Thirty-three years earlier, in 1873, Golgi had developed the black reaction, a technique that revealed for the first time the elegant detail of a neuron in its entirety. His work had launched one of the most profound scientific explorations of the era—the study of the brain at the cellular level—and established Golgi as a pioneer in the field.

The Nobel Prize committee had beckoned Golgi to the Swedish capital to be feted for his accomplishments. Under different circumstances the recognition might have been a gratifying moment of self-reflection for the reserved and ever-busy Italian. But for Golgi, it would be the last stand in an increasingly bitter fight.

In the three long decades since Golgi first devised the technique that he said could "demonstrate, even to the blind," the structure of the brain's tissue, his misguided devotion to an outdated theory had chipped away at his reputation. Once mainstream, his concept of the nervous system was now a relic. In the intervening years, his rival, Cajal, had modified and refined Golgi's black reaction to advance a new paradigm, an effort Cajal had declared, in his boisterous manner, "an act of rebellion" against the status quo—and, by extension, Golgi.

By 1906 Cajal had supplanted the Italian, discovering through his microscope elusive truths that had shaped the modern study of the nervous system. He, too, was in Stockholm that December. The prize was to be shared.

As Swedish anatomist and Nobel committee member Gustaf Retzius said, Golgi supplied "the key to open the building that encloses the secrets of the nervous system, but only Ramón y Cajal taught us how to use it."

Frost clung to the coats of scholars and scientists as they strolled through the doors of the Royal Academy of Music just before noon on December 11, entering a hall ornately decorated for the occasion. An enormous laurel wreath covered in blue and gold ribbons loomed behind the stage, where the Italian and Spanish flags were displayed together, alongside a bust of Alfred Nobel himself. The guests were all there to recognize the inextricable achievements of these two rivals who had only just met for the first time.

Golgi's speech that day would be the culmination of a dispute in the nascent days of neuroscience that was driven by ego and interpretation—a struggle to establish the theoretical foundation from which investigators would venture into the unknown depths of the brain. As he prepared to address the international scientific community, Golgi refused to yield.

The Sacred Fire of Scientific Work

Camillo Golgi was hardly destined for Stockholm. Born in 1843 in a humble house in Corteno, a tiny village in the Italian Alps, he was "quiet, thoughtful, methodical, and patient," in the eyes of his father, a physician whose path Golgi followed to the University of Pavia's medical school.

At the time, Italy's universities were slowly emerging from a period of decline. Young Italian academics trained in the more illustrious scientific communities of Germany and Austria were returning home to spread the gospel of experimental medicine.

With Italy's unification process, *il Risorgimento*, inspiring a wave of ideological change, the intensely patriotic Golgi was swept up in the positivist movement that enshrined science and the experimental method—"a weapon forged by the new school," as he called it—as the path toward unending progress. He was driven by scientific curiosity, particularly of the central nervous system, and committed himself to researching its function with exceptional rigor. But the experimental method is only as effective as the malleability of the experimenter's mind, and Golgi's rigid nature would eventually stand in his way.

For Golgi, the pursuit of scientific knowledge was "a battle not of grandiose ideas but of facts accumulated with the pertinacity of patient and tireless work" that would open the way to "new conquests." Although fiercely determined internally, he was placid on the surface, a shy man of few words who eagerly gave his spare time to research. Long after he died, his niece, Carolina, whom Golgi and his wife, Lina, had adopted in lieu of children of their own, remarked that he "lived with his thoughts" and could scarcely be described beyond his life as a scholar.

By the late 1860s, he was conducting his first histological studies of nerves while working at a clinic for patients with mental disorders. In the experimental pathology laboratory of Pavian professor Giulio Bizzozero, who later identified the role of platelets in coagulation, Golgi had access for the first time to microscopes and tools for vivisection. He took as his bible Rudolf Virchow's *Cellular Pathology*, an influential tome that declared each cell in an organism originates from another cell and identified cellular dysfunction as the cause of disease. Golgi began experimenting with a variety of staining substances and fixatives, learning how to most effectively prepare nervous tissue for examination.

For an emerging histologist, staining was the gateway to a new world. The right combination of preservatives and dyes could transform a colorless, transparent piece of tissue into a legible microscopic landscape whose cellular structures could be discerned among an otherwise muddled mass. But the science was still developing, and researchers sought better methods to see more clearly what lay before them.

Detail of the nerves cells in a dog's olfactory bulb, from Golgi's *On the Detailed Anatomy of the Central Organs of the Nervous System*, 1885.

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In 1872 Golgi was appointed chief physician of a hospital for the terminally ill in Abbiategrasso, a town on the western outskirts of Milan, where he could study tissue samples collected from twice-monthly postmortem exams. His responsibilities were minimal, allowing seemingly endless time to indulge his scientific curiosity. He yearned "to penetrate the secrets of the nervous tissue, the most noble and mysterious tissue," a student of his later wrote. "Trained to work with limited means and rich with the sacred fire of scientific work," as he later said, he set up a rudimentary lab in the kitchen of his modest apartment, where he toiled by candlelight at the microscope. He devoted himself to his "coveted goal" with "religious fervor" and "single-minded perseverance," a friend and colleague wrote. Within a year, he had found the novel staining technique that would break open the field of neuroscience.

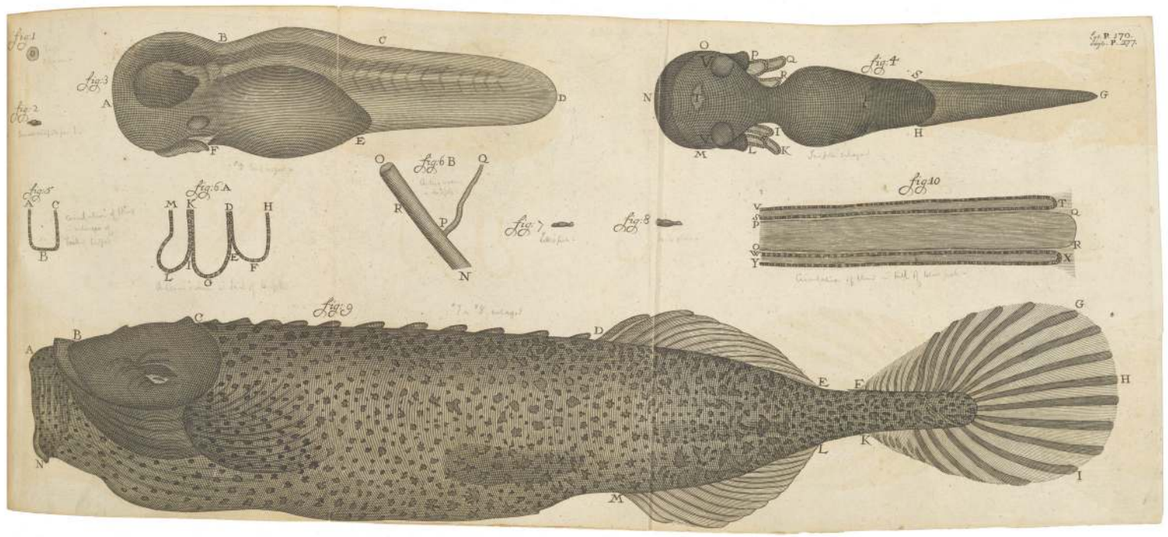
Contrast and Control

Shortly after Galileo used the telescope to peer into the infinite, English polymath Robert Hooke applied the microscope to the infinitesimal. In his landmark *Micrographia* (1665), Hooke used a homemade compound microscope to describe and illustrate the minute structure of insects, plants, and objects, including dyed hair and wool. The work became the first blockbuster science book and coined the term *cell*, but it took more than 50 years for another scientist to deliberately stain a biological object for research.

Inspired by *Micrographia*, Dutch scientist Antonie van Leeuwenhoek spent his life building hundreds of microscopes, mastering lens-grinding and flamework techniques that allowed him to look closely at anything that caught his interest, including the "wee animalcules"—single-celled organisms, such as bacteria and protozoa—that he discovered. His use of saffron to help visualize the microscopic structure of transparent tissue in 1719 presaged the histological techniques Golgi and Cajal established so many years later.

By 1770 the five-step process to prepare tissue for microscopy—fixation (or preservation), processing, embedding, sectioning, and staining—was taking shape. English botanist John Hill made the first attempt to fix and harden plant matter for study. Hill softened sticks in a stream, then macerated them in a solution of alum, dried them, and submerged them in alcohol.

Early histologists often adopted materials long used by artisans and artists to highlight elements of tissue and enhance the contrast among cell parts in their specimens. The commercial availability of carmine made it the preferred dye for the process. Derived from cactus-dwelling scale insects called cochineal, the cultivation of its powerful crimson hue dated back millennia. Nineteenth-century German botanist Theodor Hartig described carmine's propensity to attach itself to chlorophyll granules, a feature that made it a boon for plant microscopy. Hartig identified other colored substances that could serve a similar purpose, including the yellow gum resin gamboge, the scarlet mercury compound cinnabar, and cerulean copper sulfate.



A microscopic study of frog and fish specimens, from Antonie van Leeuwenhoek's *Nature's Mysteries Disclosed*, 1695.

In search of a stain that was both practical and precise, early histologists turned to indigo, gold chloride, and the aniline dyes that were just hitting the market in the 1860s. The rich blue-to-purple hue of hematoxylin, an extract from the Central American logwood tree, was particularly good at exposing cell nuclei and gave researchers one of their most potent tools. (It's the *H* in H&E staining, which remains one of histology's most ubiquitous tools.)

Staining the tissue of the central nervous system is significantly more complex than that of plant matter or even other human tissue. Nerve tissue deteriorates quickly and is densely packed with cells, complicating the task of bringing into adequate contrast each cell's distinct elements, including the dendrites and axons that extend from the cell body in opposite directions. By leaving a piece of tissue overnight in diluted carmine, the German anatomist Joseph von Gerlach found a way through this impenetrable wall. The extended time in a less concentrated solution finally revealed the differentiation that he and others had been seeking. His 1858 paper on the results demonstrated a level of control over staining technique that encouraged others to try their hand and ignited histological exploration across Europe.

As von Gerlach continued his research, he theorized that nerve cells were connected to one another by a network in which their dendrites and axons branched minutely and endlessly into one another to form a densely interconnected forest. In this continuum, von Gerlach theorized, nerve cells were placed in constant anatomical and functional connection. The reticular theory, as it came to be known—a reticulum being a network or netlike structure—usurped the cell theory promoted by Virchow and others to become the standard explanation for the operation of the brain. In Abbiategrasso, Golgi quickly fell under its spell.

An Instrument of Revelation

As histology was maturing, a seemingly disparate craft was developing simultaneously that would offer Golgi a tool to gaze into the forest of the central nervous system and see individual trees and their branches for the first time.

Early photographic experimenters in the 18th and 19th centuries noticed the propensity of silver salts to darken when exposed to the sun. By the 1830s, researchers observed that paper bathed first in sodium chloride and then in silver nitrate darkened into shades of varying intensity to reveal the contours of images projected onto it. A rush of technological improvements followed, and crowds and critics were awed by the "divine perfection" of mysterious photographic methods. Artists and scientists, professionals and amateurs of all stripes quickly adopted the tools. Years later, in Spain, a young Cajal found himself "stupefied" by photography and the chemical processes that could conjure a latent image, bringing the seemingly invisible into view.

Soon, silver nitrate would be the key ingredient in another scientific breakthrough.

As he poured himself into histological research and experimentation, Golgi focused his attention on the nervous system's connective substance, what Virchow had called neuroglia, or nerve-cement. Golgi was able to describe their varied shapes—rounded, lenticular, stellate—and attracted international attention for his writings on their relationship to nerve cells. But he recognized the need to move beyond the usual histological techniques in search of those that could "match the special and complex structure" of the nervous system.

Although carmine predominated in the early days of histology, silver nitrate had occasionally been used to stain intercellular substances black. In early 1873, Golgi wrote to a friend to say that he had expanded on this approach by letting silver nitrate react on pieces of brain hardened in potassium dichromate for as long as 45 days. He had "obtained magnificent results and hope[d] to do even better"—magnificent because his concoction mysteriously impregnated only a few cells in a sample with the darkened silver. For reasons that still remain unclear, the black reaction, as Golgi dubbed it, generally stained less than 5% of the microscopic field.

Golgi's method produced an image with a level of contrast and clarity previously unseen. Where von Gerlach saw trees branching toward one another in a dusky forest, Golgi could now distinguish not just limbs but the finest twigs and shoots of each individual, starkly shadowed against the pale yellow of a morning sky. One of his students later described its "marvelous beauty . . . which allows even the layman to appreciate the images in which the cell silhouette stands out as if it had been drawn by Leonardo da Vinci" and nerve fibers intertwine "with the most sophisticated elegance."

Armed with this transformative new tool, Golgi began to develop his own version of the reticular theory, which he called the "diffuse neural net." He insisted that the central nervous system worked as one holistic unit in which electrical impulses are carried throughout by physical connections that bond one nerve cell directly to another. He differed from other reticular theorists by claiming axons alone—and not dendrites, as had previously been suggested—formed the reticulum. Against all evidence that emerged in the years to come, he would remain a prisoner to this idea.

Though Golgi's black reaction would eventually earn him an invitation to Stockholm, it took more than a decade for the international scientific community to take notice. He published his findings in a journal with limited circulation, and they lacked the illustrations that would have brought the great leap to life. Among the few foreign scientists who immediately recognized the technique's potential, however, was Cajal, who saw in the "happy peculiarity" of the black reaction's inexplicable selectivity "the instrument of revelation."

The Dream Technique

If Golgi's path to Stockholm was unlikely, his counterpart's journey was even less predictable. Santiago Ramón y Cajal was born in 1852 in the highlands of the Aragon region of Spain, where the Pyrenees mountains loomed to the north. As with Golgi, the nation of Cajal's youth was defined by political turmoil—incessant uprisings, government overhauls, and rewritten constitutions. Napoleon's invasion of Spain more than 40 years earlier had driven its economic and political systems to the point of collapse, taking its scientific institutions along with them. Spain had remained a scientific backwater ever since, but Cajal would help resurrect the country's standing.

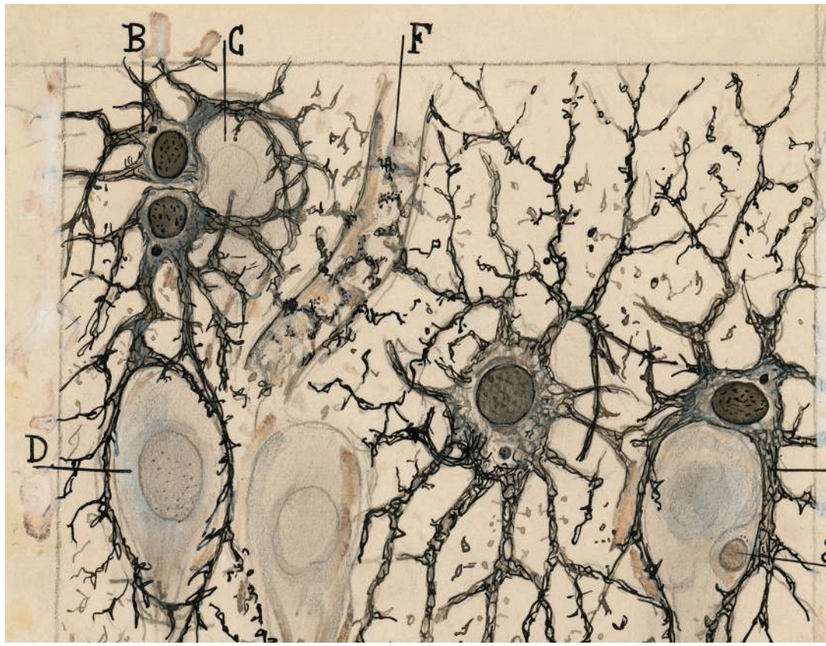
As a boy, Cajal was seized by an "irresistible mania" to draw. Every surface he encountered was a canvas. His brother, Pedro, said he "entered the castle of science through the door of art." For Cajal, art was a way of understanding the world around him. Even from his first microscopic explorations, he drew what he saw in detail, with all the shading and color of the real thing.

Cajal's father was a barber-surgeon, a centuries-old profession. Since medieval times, the barber's facility with a blade made him, rather than a physician, the man to see for minor surgeries and bloodletting. At his father's hand, Cajal learned anatomy through the dissection of cadavers, drawing hundreds of sketches of the structures he and his father uncovered with their scalpels.

The Glorious Revolution of 1868, which ended the tumultuous and controversy-scarred reign of Queen Isabel II, sparked a revival of Spanish science. Translated foreign texts, including Virchow's book popularizing cell theory, ignited new ways of thinking about the body and medicine, replacing old ideas that posited the soul as the source of healing. For Cajal, the book was a revolution all its own. Like Golgi, he enrolled in his father's medical alma mater in Zaragoza, Aragon's capital. There, he saw his first preparations under a microscope. A frog lay paralyzed on its back, its intestines removed, and its lymph sac injected with carmine, staining its cells bright red. As he observed red and white cells rushing through its bloodstream, Cajal found himself deeply moved. "It was as though a veil were suddenly lifting from my soul," he wrote.

From that point forward, Cajal was inseparable from his microscope. At one point in middle age, during a two-week stay in the London home of neurophysiologist Charles Sherrington, Cajal turned his guest room into a laboratory, refusing to pause his investigations. He and Golgi shared a devotion to their work above all else. "Are there Sundays in nature?"

Astrocytes and neurons in a human hippocampus, by Santiago Ramón y Cajal, ca. 1900.



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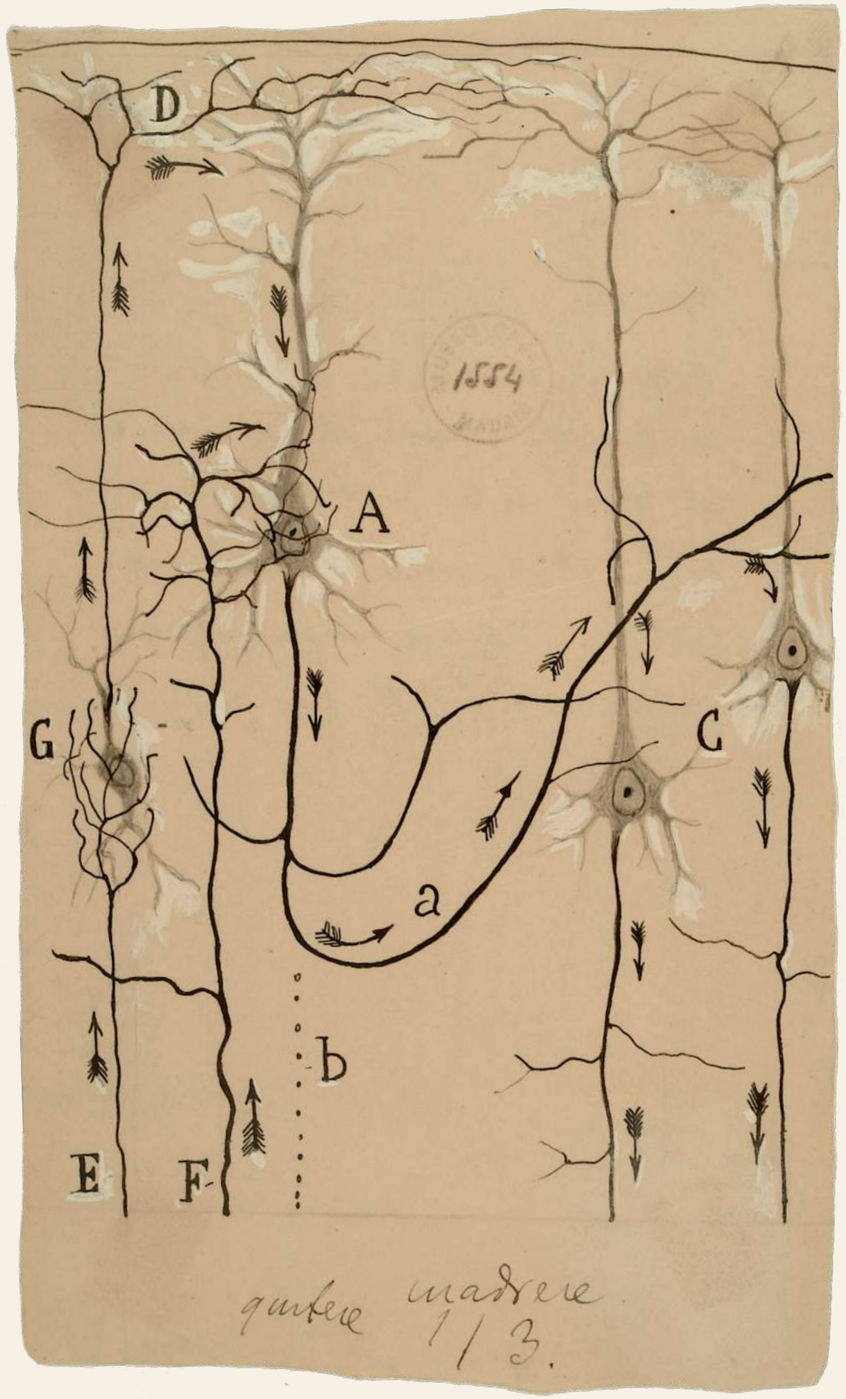

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LEFT Study of pyramidal cells in the cerebral cortex in which Cajal proposes the directional flow of information, 1914.

he once wrote, questioning the merits of rest. He and his wife, Silveria, had seven children, but the warmth of family life could not draw him away from research. "Children of the flesh should not drown out the children of the mind," he wrote.

On his 32nd birthday, in 1884, Cajal published his first textbook, 192 pages detailing for other Spaniards the best contemporary methods for microscopy and staining. It wasn't until a few years later, though, that he encountered the black reaction. In the lab of a colleague fresh off five years studying with the elite in Paris, Cajal saw preparations of neurons he described as looking like "Chinese ink on transparent Japanese paper." What had been an "inextricable network" when stained with carmine and hematoxylin was now "simple, clear, and unconfused." "The dream technique," he declared, "is a reality!" Within a year of witnessing the black reaction, Cajal had abandoned all other work to study nervous tissue.

Protoplasmic Kisses

The question driving Golgi and Cajal's work was the same: How does the nervous system function? To answer it, they needed to understand the course of an electrical impulse—the path from stimulus to response. A century earlier Italian physician Luigi Galvani had experimented on frogs to discover what he called "animal electricity," an innate force that activated the body's nerves and muscles. But how those impulses traveled throughout the nervous system was yet unknown.

For Golgi, the interconnectedness of the system was its own answer. The reticulum offered "the greatest variety and the greatest complexity" of relationships between nerve fibers, he argued. Cajal, though, wanted to know how the nervous impulse within a nerve cell actually moves: "in all directions, like sound or light or . . . constantly in one direction, like water in a watermill." Cajal needed incontrovertible proof to believe that nerve fibers maintained a physical connection, and Golgi hadn't yet offered it.

Cajal's was a single-minded pursuit: Of the 45 papers he published from 1888 to 1891, every one included the word *connections* in the title or subtitle. In search of the connections Golgi insisted upon—or the evidence that they didn't exist—Cajal sought to improve the black reaction's clarity, staining tissue multiple times with silver nitrate, submerging samples for longer periods of time, or employing more concentrated solutions. Over months of practice and repetition, he reached the level of detail he needed, using a "double impregnation" technique that allowed the stain to penetrate thicker sections of tissue, revealing more about the nerves he was studying. Although he was never able to directly observe the space between neurons, he believed that the absence of color in his preparations represented those gaps. Always, he drew, making nearly 3,000 elegantly detailed sketches over his lifetime of the intricacies of nerve cells and the connections he did and didn't see.

Under the microscope, Cajal, like Golgi, saw the dense tapestry of the nervous system, a web of ordered chaos, so many spindly roots thinning as they stretched out from a cell in search of connection. But unlike Golgi, he did not deceive himself into believing he saw those connections made real.

"The question driving Golgi and Cajal's work was the same: How does the nervous system function? To answer it, they needed to understand the course of an electrical impulse—the path from stimulus to response."

In studying the retina and olfactory bulb, a segment of the forebrain that processes odors, Cajal realized that dendrites were oriented toward the external world and axons faced inward toward the body's nervous organs. He determined that this orientation defined the path of nervous impulses (from dendrites, to the cell body, to axons) and called this the law of dynamic polarization. With his refined staining technique, he was now confident that dendrites and axons both "terminate freely," refuting Golgi's argument for physical connection. The impulse is carried across the gap—later described by Sherrington as a synapse—"in much the same way that electric current crosses a splice between two wires," Cajal wrote. For the Spaniard, who had grown up reading *Don Quixote* and other great literature and wrote fantasy of his own, the inner workings of the nervous system evoked literary romance. Communications between nerve cells were "protoplasmic kisses," he wrote, "the final ecstasy of an epic love story."

In 1889, he wrote to Golgi to say that he was prepared to present his findings and declare the independence of the nerve cell at an international conference in Berlin. He hoped to visit Golgi in Pavia on his trip home. "My preparations are so clear, so analytical, that all doubts concerning certain facts are absurd," he told the Italian, who by then had put aside research into the nervous system to focus on infectious disease and was in the process of identifying the parasites responsible for malaria and their relationship to fever. Golgi dismissed Cajal, sending back a paper on his malarial research.

At the conference, Cajal's colleagues were "enchanted" by what his slides showed, Retzius said, and surprised that such significant research could have emerged from Spain. Many committed to returning home and applying Golgi's method—perfected, as it was, by Cajal. Golgi had finally been recognized for his staining technique, but it was Cajal's description of the nervous system's function that now dominated scientific thinking.

Formidable Enemies

Cajal may have professed his admiration for Golgi's "seminal and path-breaking experiments" and the "precious method" he shared with the world, but he viewed the reticular theory as a "formidable enemy." Golgi, a man with an "iron will," a "singular voice," and a "vast and strong forehead," as one scientist wrote after meeting him, was the theory's most vocal advocate. To Cajal, whose investigation of nerve cells sometimes veered into psychology, the black reaction had offered a light by which to explore "the utter darkness" of the mechanisms of human behavior. To assert that the entire central nervous system exists in a constant state of connection was to declare "the absolute unsearchability of the soul."

Following the conference in Berlin, the scientific community coalesced around Cajal's theory of the individuality of nerve cells, which in 1891 was described by German anatomist Wilhelm von Waldeyer as the neuron doctrine—neuron referring, in the original Greek, to sinew and nerve, among other objects. (Waldeyer also coined the term *chromosome*.)

Despite the shifting tide, Golgi stubbornly continued to fight for his theoretical interpretation. As he approached his 50s, his chestnut hair beginning to gray and his prodigious forehead expanding, his interest in nerves was reignited by the "strenuous opposition" his hypothesis had attracted, as he detailed in a paper attacking the neuron theory and the law of dynamic polarization. Those who disagreed with him—Cajal, most notably—were concerned more with "doctrinal conceptions than on new proven facts," he wrote. "I must ask if this is really doing anatomy or rather exercising imagination." Even the word *neuron* itself, he said, "cannot claim any well-grounded right to citizenship in science." Cajal, meanwhile, lamented reticular theory as a "contagion" and its adherents as "fanatics" driven by "an anarchical and calamitous passion."

At conferences, in journals, in lectures, and in correspondence with other scientists, the rivals waged ideological war. Still, as they pushed forward in their research, they seemed to orbit one another. Cajal did visit Pavia on his return from Berlin in 1889, but Golgi wasn't there, and the chance to bridge the gap between the histologists was lost. Five years later, both men spoke at an international conference in Rome, along with Virchow, a shared inspiration. Cajal discussed the morphology of nerve cells, while Golgi served on the conference's executive committee. But Cajal's meticulous memoir makes no mention of them meeting.

Still, they remained entangled. When Cajal published his discovery of delicate fibers, which he called "collaterals," branching from axons in the spinal cord of chicken embryos, Golgi was incensed. A decade earlier he had made the same finding, but it had gone unnoticed in the provincial Italian journal that published it. Golgi's subsequent discovery of the organelle that now bears his name provided a bit of symmetrical irony. He found a "fine and elegant reticulum hidden in the cell body" in 1897—several years after Cajal had obtained images of a similar structure in pieces of a young rabbit brain but opted against publishing the observation because he was unable to reproduce his finding.

In 1903, Cajal vacationed in Italy and once again made a stop in Pavia; Golgi, however, was on his own vacation elsewhere. While taking photographs in Rome, Cajal conceived of yet another new staining technique, reducing silver nitrate with the developing agent pyrogallic acid to create photosensitive compounds that would blacken upon exposure to light, revealing even more about the inner structure of nerve cells. It allowed him to prove that nerve fibers form only within cells and not between them—a final nail in the coffin of reticular theory.

Golgi, however, would not relent. Three years later, the Nobel committee made the controversial decision to split the prize between him and Cajal, despite Golgi's primary discovery being now long in the past and his conceptual framework giving way to Cajal's. Golgi, who believed the Spaniard was ill and unable to travel to Stockholm, was stunned to emerge from his train and see Cajal among those waiting to welcome him, insistent upon finally meeting his rival. In the biting Scandinavian air lay one last chance to break the ice between them. Instead, Golgi stormed to his hotel to revise and rehearse the Nobel lecture that might wrest back his scientific authority.

Santiago Ramón y Cajal, 1885.

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A Relic of the Past

At the Nobel ceremony on December 10, the president of the institute administering the award praised Golgi as the "pioneer of modern research in the nervous system" and Cajal as the man who had "given the study of the nervous system the form that it has taken in the present day." But when Golgi stepped up to deliver the prizewinner's customary address at noon on the 11th, he dispensed with any such harmony. The audience was stunned as he launched into an attack on the neuron doctrine that betrayed his bitterness at seeing his own work turned against him.

Rather than expounding his own findings, as was typical in such a lecture, Golgi claimed that the neuron doctrine was "generally recognized to be going out of favor." He lamented that he was "unable to follow the current of opinion" that declared the "so-called physiological independence of the neuron," and he scoffed at Cajal's law of dynamic polarization. He saw no reason to give up his concept that nerve cells acted together, rather than individually. "I cannot abandon the idea of a unitary action of the nervous system," Golgi said. He didn't care if his stubborn belief tied him to a theory others had cast aside.

After so many years spent lobbing scientific salvos at one another, the mild-mannered Golgi had taken aim directly at Cajal—and, in the process, ignored or diminished the contributions of many of the scientists, including Retzius, who had shared in his explorations and achievements. Cajal, whose work Golgi subtly critiqued as "frequently plausible," joined members of the audience who watched in "stupefaction," he later wrote. Cajal recalled "trembling with impatience" and being desperate to intervene, wishing to correct his rival's "odious errors" and "deliberate omissions." He wanted to put the past in its place and turn the page toward progress.

At his own lecture the following day, Cajal gave a more traditional address with that aim in mind. But he allowed himself one parting shot. "It would be very convenient and very economical" if nerve cells truly did form a continuous network, as Golgi argued. "Unfortunately," Cajal said, "nature seems unaware of our intellectual need for convenience and unity, and very often takes delight in complication and diversity."

The Cruel Irony of Fate

Golgi and Cajal continued a distant scientific exchange of sorts after Stockholm. Golgi returned to studying the internal reticular apparatus and found an improved method for staining it, using a modification of Cajal's reduced silver nitrate technique. Despite his varied contributions, his scientific standing never recovered. The second volume of Cajal's memoir, *Recollections of My Life*, published in 1917, offered harsh attacks on Golgi that became the basis for his international reputation in the years to come. Even in Pavia, Golgi became known not for his discoveries but for his errors. Rather than the forefather of neuroscience, he was the man who let pride stand in the way of progress.

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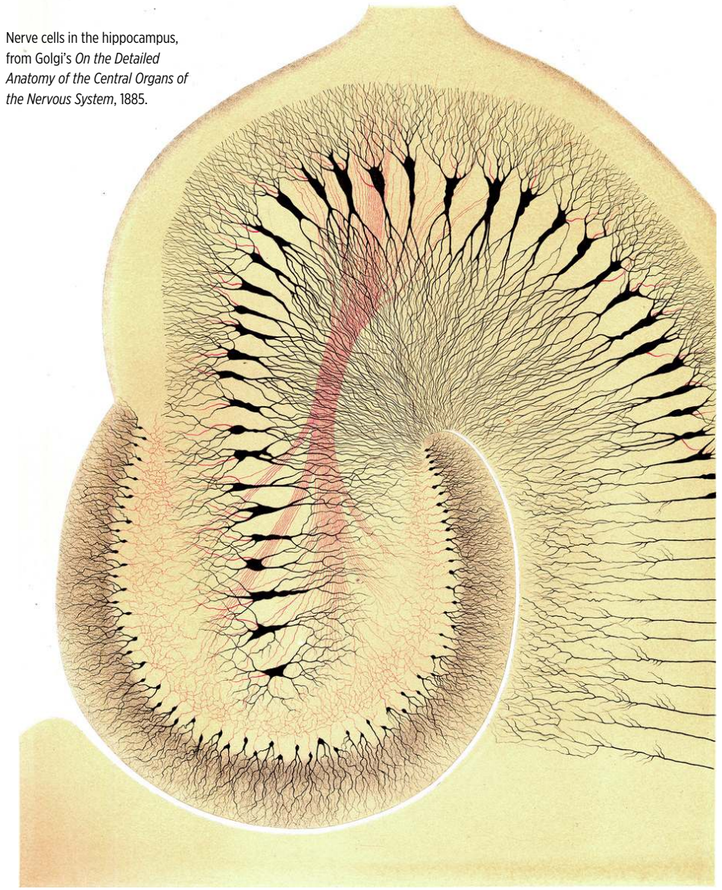

Nerve cells in the hippocampus, from Golgi's *On the Detailed Anatomy of the Central Organs of the Nervous System*, 1885.

Cajal, meanwhile, developed two more histological techniques to better reveal neuroglia, contributing to researchers' realization that beyond neurons lay an assortment of cells in the nervous system more diverse than they had previously grasped. As he grew older, he was preceded everywhere he went by the fame he had achieved for his discoveries and that had been cemented with the Nobel. Bands played for him in public, students applauded at the sight of him, and statues went up while he still lived. He became a monument to Spain's scientific might. In 1956, Sanford Palay, an American neuroscientist, used the electron microscope to produce the first images of a synapse. He wrote that it confirmed Cajal's theory, referencing him by name.

Like two neurons, Golgi and Cajal stood on opposite sides of a chasm, a synapse that separated them as they sought to perceive what had forever been invisible. Despite this gulf, a kind of current passed between the two rivals, a stimulus and response that carried neuroscience into a new era. From their feud emerged the technical tools to explore the brain's building blocks and the theoretical framework by which to understand its function.

"What a cruel irony of fate," Cajal wrote after the Nobel lectures, "to pair, like Siamese twins united by the shoulders, scientific adversaries of such contrasting character!" D

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IN THE SHADOW OF OPPENHEIMER

how popular narratives of the atomic age obscure the bomb's first victims

STORY BY JOSHUA WHEELER PHOTOGRAPHY BY RETO STERCHI

A version of this story previously appeared in Swiss magazine *Republik*.

According to most accounts, the desert was uninhabited. The stories will tell you that when the first atomic bomb was detonated on July 16, 1945, hardly anyone lived nearby.

A 2015 PBS documentary about the test, codenamed Trinity, begins, "Here, miles and miles from anywhere. . . ." In his Pulitzer Prize–winning history, *The Making of the Atomic Bomb*, Richard Rhodes writes of the Trinity test, "A bomb exploded in the desert damages not much besides sand and cactus and the purity of the air." And the biography *American Prometheus*, another Pulitzer Prize winner on which this summer's $100 million blockbuster *Oppenheimer* is based, depicts physicist Robert Oppenheimer roaming New Mexico in 1944, "searching for a suitably isolated stretch of wilderness where the bomb could be safely tested." And yet, a few sentences later, the writers of *American Prometheus*, Kai Bird and Martin Sherwin, stumble into a contradiction. Upon choosing a location in southern New Mexico, "the Army staked out an area eighteen by twenty-four miles in size, evicted a few ranchers by eminent domain and began building . . . bunkers from which to observe the first explosion of an atomic bomb."

It's those evictions that make the choice of Trinity's location so haunting. Robert Oppenheimer and the Manhattan Project knew from the start that this place was not all that isolated and was far from uninhabited.

There were, in fact, dozens of families within 20 miles, largely poor families of ranchers and farmers, many Hispanic and Indigenous, who unwittingly went about their daily lives in the first fallout of the atomic age. Now, those who were infants and children downwind of the detonation of the "Gadget"—a code name for the plutonium bomb used in the Trinity test—are nearing the end of a decades-long battle to be recognized and compensated for generations of illness they trace to exposure from radioactive fallout.

Fireworks stands outside of Tularosa, New Mexico.

TWO MONTHS BEFORE the Gadget exploded, scientists and soldiers gathered at the Trinity site to hold what they called a "rehearsal." At dawn on May 7, 1945, they detonated nearly 100 tons of TNT spiked with plutonium. In the dark hours before this pretest, Manhattan Project doctors used battery clips to leash live rats to wires positioned around the mountain of explosives. The doctors were concerned the coming atom bomb test might create dangerous radioactive fallout. This last-minute experiment, poorly designed and executed, yielded no results: the rats closest to the blast were incinerated totally, while those further off were blown free of their wires and never recovered. One might think that researchers familiar with the complex and intricate physics used to engineer the atomic bomb would be able to conduct a less crass experiment; but the rat test, in all its callous ineptitude, was wholly characteristic of the American approach to radioactive fallout in the early days of nuclear weapons development.

When, two months later, the first atomic bomb was finally tested, it was done over the objections of doctors and a meteorologist who warned the weather that morning was likely to spread fallout far and wide over New Mexico's civilian population. "Right in the middle of a period of thunderstorm," the meteorologist complained in his journal of the scheduled test, "What son-of-a-bitch could have done this?"

As the storm raged in the hours before the test, Italian physicist Enrico Fermi warned Oppenheimer, "There could be catastrophe." Oppenheimer took a break from reading the poetry of Baudelaire to relay to the military his version of the warning: "The weather is whimsical." The decision was made to proceed with the test.

The exploding Gadget brought to a stretch of New Mexico desert the kind of heat that until then had existed only at the cores of stars. It was just before 5:30 a.m., and the sun was yet to rise, but for a few seconds there was absolute light, otherworldly in its intensity and visible for hundreds of miles. The shockwave broke windows 180 miles west at a bar in Silver City. Liquified sand rose with vaporized steel and the bomb's plutonium to form a mushroom cloud 38,000 feet high. Then came the wind, scattering the cloud, its ash coating the land as chunks of green glass formed when the sand cooled and fell from the sky. Eighty percent of the bomb's plutonium core failed to fission, making that first bomb a "dirty bomb" by today's standards, and all of that radioactive material spread across New Mexico and beyond. By the end of the week, the fallout would ruin a batch of film at an Eastman Kodak factory in Indiana, the wind having carried traces of the Gadget more than a thousand miles.

The reactions of Manhattan Project observers at the Trinity site are well documented. "Words haven't been invented to describe it," physicist Val Fitch said of the enormous fireball. General Thomas Farrell said the awesome roar "warned of doomsday and made us feel that we puny things were blasphemous." "A few people laughed, a few people cried," Oppenheimer recalled years later. "I remembered a line from the Hindu scripture . . . Now I am become Death, the destroyer of worlds." Physicist Kenneth Bainbridge said, "Now we are all sons of bitches."

Less documented are the reactions of the many New Mexicans who lived near Trinity. They had no warning, no context for the star-level explosion that shook their homes and startled them awake that morning. Worse, in the weeks after the test, they were never advised that their land, crops, livestock, and water may have been irradiated. A 2010 report to the CDC used archives at Los Alamos National Laboratory to re-examine the extent to which New Mexicans were unknowingly exposed to radioactive contamination from Trinity. Its findings revealed a shambolic and sometimes cynical effort to track the Gadget's fallout that windy morning using "crude" and "ineffective" measures. Spotlights were deployed to try to follow the 230 tons of sand and ash falling from the mushroom cloud as it dispersed over southern New Mexico. Film badges designed to detect and measure radiation had been sent to nearby post offices before the test, but because of the Manhattan Project's secret nature, there was little explanation on how the badges were meant to be used or why, and so they were deployed incorrectly or not at all.

Some soldiers assigned to chase and monitor the radioactive cloud couldn't relay their findings to headquarters in Albuquerque because they were not equipped with long-distance radios; other monitors attempted to gather fallout samples with domestic Filter Queen brand vacuum cleaners. (These samples were later lost or destroyed.) At least one monitor left the area after his superior declared tracking fallout a "waste of time," while another soldier misplaced his respirator and took the official but scientifically misguided precaution of breathing through a slice of bread.

In any case, the preparations for fallout monitoring appear to have been as much about defending against possible litigation as protecting the health of anyone who might have been affected. A recent article in *Nuclear Technology* reports the instruction for monitors was to "keep as complete notes as possible in your own handwriting. . . . These notes can be written up more fully at a later date but in any court proceeding it is necessary to have your original data."

But data about the aftermath of Trinity remains scarce. "No one really wanted to pursue the radiation possibilities for fear of getting involved in litigation," said chief Manhattan Project medical advisor Stafford Warren in an interview with Lansing Lamont for his book *Day of Trinity*.

"The army and government lawyers," Warren said, "wanted to put it all out of sight and mind as quickly as possible."

IN THE HOURS after the explosion, when areas of high radioactive fallout were discovered at a ranch just 12 miles from Trinity, one doctor in charge of safety, Louis Hemplemann, decided against evacuation, likely in part because of constant pressure to maintain secrecy coming from Leslie Groves, the army general in charge of the Manhattan Project.

"Groves did not seem concerned about safety," says James L. Nolan Jr., a professor of sociology at Williams College and the author of *Atomic Doctors: Conscience and Complicity at the Dawn of the Nuclear Age*. He knows about Groves' attitude toward safety in part because his grandfather, James F. Nolan, experienced it firsthand.

The elder Nolan worked for the Manhattan Project and, one month before the Trinity test, he presented Groves with a report outlining the dangers of radioactive fallout as well as detailed safety measures that might be taken, including plans for extensive evacuations. Groves dismissed the report, saying, "What are you, some kind of Hearst propagandist?"

"The massive explosion that rocked their homes, filled the horizon with a mushroom cloud, and covered their land in "ashy snow" was dismissed in press releases the next day as nothing more than a small detonation at the munitions dump."

Scenes from a town hall meeting in Tularosa, New Mexico, organized by the Tularosa Basin Downwinders Consortium, July 2021.

"If there was a chance to minimize consequences, that was one," says Nolan Jr. But his book—a damning account of American missteps told through the lens of his grandfather's work on numerous atomic weapons operations—details doctors' consistent efforts to mitigate civilian exposure to fallout that were consistently ignored or diluted.

Atomic Doctors reveals that many in the Manhattan Project were ultimately clear-eyed about their mistakes, if not quite apologetic. Hemplemann, for instance, stated after Trinity that, given the known dangers of fallout, the pressure of secrecy, and the rush to have a working bomb in time for President Harry Truman's July 17, 1945, meeting with Winston Churchill and Joseph Stalin, "We really shouldn't have done the test." He later wrote in his memoirs, "A few people were probably overexposed, but they couldn't prove it and we couldn't prove it, so we just assumed we got away with it."

Attendees at the Tularosa Basin Downwinders Consortium's 2021 candlelight vigil.

THE 1940 CENSUS recorded 121 people living within 20 miles of Trinity. At 50 miles, there were more than 13,000 people, including all the residents of the villages of Carrizozo and Tularosa, much of the city of Alamogordo, and parts of the Mescalero Apache Reservation. The larger cities of Albuquerque to the north and El Paso to the south were each less than 200 miles away.

Radiation monitors tracked the Gadget's fallout so far from ground zero that Stafford Warren recommended future nuclear weapons tests should maintain a minimum 150-mile radius without population. (While future test sites in Nevada and Utah were established further from populated regions, they never adhered to this recommendation. For instance, Las Vegas is only 100 miles from the Nevada Test Site. Both Nevada and Utah have well-documented histories of communities near test sites suffering from fallout-linked illnesses.)

When the evening of the Trinity test brought heavy rains, doctors noted the threat to nearby ranchers: "some of the activity [fallout] was carried into their drinking water and may have been drunk on the following day and thereafter."

Ingestion of radioactive plutonium was of concern for the Manhattan Project since at least 1944, when a chemist accidently swallowed some while performing an experiment known as "tickling the dragon's tail." That incident led Oppenheimer to approve human experimentation in hopes of measuring the dangers of plutonium ingestion. One month before they incinerated rats with radioactive TNT and three months before the Trinity test, Manhattan Project doctors began secretly injecting hospital patients with plutonium in a horrific program of unwitting radiation exposure that would last until 1947.

In 1995 President Bill Clinton apologized for the plutonium injection experiments, saying they "failed both the test of our national values and the test of humanity. . . . Americans were kept in the dark about the effects of what was being done to them . . . not for a compelling reason of national security but for the simple fear of embarrassment, and that was wrong."

Members of the Tularosa Basin Downwinders Consortium preparing for the organization's annual candlelight vigil, July 2021.

Scenes from the Tularosa Basin Downwinders Consortium's 2021 candlelight vigil.

Since 1990, the government has sought to address some of these early atomic-era failures of national values and humanity through the Radiation Exposure Compensation Act (RECA). This act allows for one-time payments of $50,000 to citizens exposed to atmospheric nuclear tests, known as downwinders, as well as $100,000 payments to uranium miners, mill workers, and other laborers in the nuclear weapons industry. But despite the country's extensive nuclear weapons testing—more than 1,000 tests at over a dozen locations, from the Pacific Ocean to the Atlantic Ocean, from Alaska to Mississippi—RECA has been limited to downwinders with radiation-linked illnesses in only a handful of counties in Nevada, Arizona, and Utah. And one year from now, in June 2024, RECA is set to expire permanently.

One group at the forefront of the fight to extend and expand RECA is the Trinity downwinders in New Mexico. Despite being the first people in the world exposed to radioactive fallout, they've never been eligible for compensation, and they've never gotten a clear answer why. Many interpret their exclusion as an extension of the secrecy and obfuscation that surrounded the Manhattan Project from the beginning. And so, for decades the New Mexicans who lived closest to Trinity have tried to change the narrative of the Manhattan Project to include stories of the poor, Hispanic, and Native American communities that were exposed to the Gadget's fallout on July 16, 1945. With all the hype surrounding a star-studded film about Trinity this summer, these folks worry their struggles may once again be overshadowed.

"The Manhattan Project was an invasion of our land and lives," says Tina Cordova, whose family lived in Tularosa just 50 miles from Trinity in 1945. "And the film feels like that too. Without all the Hispanic and Native people . . . Los Alamos doesn't exist . . . the Manhattan Project doesn't happen . . . but we don't think they'll ever tell that story."

These rural communities, like the one in Tularosa where Cordova's family lived, generally had no electricity or running water in 1945. They drank from open cisterns that collected rainwater. If they had a well, its water was brought by windmills to surface holding ponds in the open air. They grew much of the food they ate. They raised their own livestock for meat and milk.

The massive explosion that rocked their homes, filled the horizon with a mushroom cloud, and covered their land in "ashy snow" was dismissed in press releases the next day as nothing more than a small detonation at the munitions dump. There were no warnings issued. Despite the storm having scattered fallout unpredictably and the detection of excessive radiation in numerous communities, no evacuations were ordered. And so these families went on drinking from their irradiated cisterns, using water from their irradiated ponds and ditches for cooking and cleaning, and eating their irradiated crops and livestock because their government assured them there was no danger.

It was only three weeks later, after the bombing of Hiroshima on August 6, that the explosion in New Mexico was revealed to be an atomic bomb. But even then, the army publicly maintained for long afterward that any fears of radiation sickness from nuclear weapons were only "enemy propaganda."

"Eighty percent of the bomb's plutonium core failed to fission, making that first bomb a "dirty bomb" by today's standards, and all of that radioactive material spread across New Mexico and beyond."

THE PRESSURE TO remain quiet about radiation exposure is a tradition in New Mexico. The state's economy has long benefited from the nuclear weapons industrial complex, as it is the only state with a so-called "cradle-to-grave" industry where uranium is mined, weapons developed, and waste stored. In 2003 *Democracy Now* reported that "if New Mexico seceded it would be the third biggest nuclear power in the world." Others have described the proliferation of nuclear weapons in one of the poorest states in the nation, with one of the highest populations of Indigenous and Hispanic residents, as "nuclear colonialism."

Now, 78 years after the atomic age began, the last living witnesses of the world's first radioactive fallout are those who were, at the time of the test, the youngest and most vulnerable. They've spent decades calculating the ravages of cancer in their communities. At a recent downwinders memorial in Tularosa, a village of 2,641 where 65% are Hispanic and the median income is $25,000 less than the national average, more than 700 luminarias were lit in remembrance of cancer victims from the region.

A study by the National Cancer Institute published in 2020 concluded that "there is great uncertainty in the estimates of radiation doses and number of cancer cases possibly attributable to the [Trinity] test, thus no firm estimates can be established." This even as a 2010 CDC study concluded that "exposure rates in public areas from the world's first nuclear explosion were measured at 10,000 times higher than currently allowed."

Conservatively, the United States has spent $6 trillion developing nuclear weapons. Since 1990, RECA has paid an estimated $2.5 billion to compensate people with illnesses linked to nuclear weapons development. This compensation amounts to less than 0.0005% of the nation's total spending on nuclear weapons. And with funding for nuclear weapons growing, that number will effectively become zero when RECA ends next year.

The downwinders of Trinity are just one of many groups of Americans who have been given no opportunity to seek redress for developing cancer and other chronic illnesses after exposure to their nation's nuclear weapons industrial complex. In 2022, Senators Ben Ray Luján (D-NM) and Mike Crapo (R-ID), along with Congresswoman Teresa Leger Fernández (D-NM), introduced legislation to extend and expand RECA for communities such as Tina Cordova's in Tularosa. The bill would have extended compensation to communities downwind of atmospheric nuclear weapons tests in Colorado, Idaho, Montana, New Mexico, and Guam, as well as expanding the number of eligible uranium miners, such as the many Navajo who worked the mine on their tribe's reservation in northern New Mexico. But the bill failed to move forward. This year the effort to amend RECA seems to have fractured, with legislators from three different states sponsoring three different bills, none of them as inclusive or expansive as the previous efforts.

Cordova, who has testified before Congress on this issue, is concerned the new efforts may fail. "Here we are again," she says, "this never-ending cycle of introduce bills, ignore them . . . and people continue to die and get sick in all of our communities."

"Countless Americans continue to battle cancer and other diseases caused by this exposure, yet too many receive no compensation from the government for the harmful effects," Leger Fernández wrote to me in a statement last year. "In New Mexico, where the Trinity Test occurred, downwinders are not eligible for assistance. The current law also senselessly leaves out post-71 uranium miners [who began working after 1971]. We must expand the law to ensure that all those affected can receive fair compensation."

The downwinders in New Mexico have sometimes described themselves as "lab rats," invoking notions of those actual rats lost or vaporized in the rehearsal for the Trinity test. It's reminiscent of another moment from *American Prometheus*, one that lacks the explosive action typical of a summer blockbuster but nonetheless encapsulates something important about the true nature of Trinity. It was 1961 and Oppenheimer was on vacation. He watched his friend catch a turtle on the beach. But when his friend wanted to cook the turtle, Oppenheimer objected. "Wincing, Robert pleaded for the turtle's life, telling everyone that it 'brought back to him the horrible memories of what happened to all the little creatures after the [Trinity] test in New Mexico.' "

Scenes from the Tularosa Basin Downwinders Consortium's 2021 candlelight vigil.

"The downwinders in New Mexico have sometimes described themselves as "lab rats," invoking notions of those actual rats lost or vaporized in the rehearsal for the Trinity test."

I FIRST BEGAN speaking with the downwinders of Trinity in 2015, while researching my book *Acid West*. But I was raised in Alamogordo, just 60 miles south of the Trinity site, and in that way I had been speaking with downwinders much of my life—I just didn't know it. Like many in the region, my experience of the Gadget was limited to the dramatic stories of scientists or mutants that I encountered in movies and comic books. Also there were the tours the army conducts at the Trinity site in October and April of every year, allowing visitors to traipse around a small monument they've installed at ground zero. But the monument commemorates only the bomb. There is nothing to commemorate the bomb's victims, American or Japanese. And the place really does feel isolated now. Eventually the government claimed 3,200 square miles around the Trinity site and fenced it off, creating the nation's largest overland military range. The only trace of the people who once lived in the area is the McDonald House. The McDonalds were one of the families evicted before Trinity. Their house, largely unchanged, became the place in which the Gadget was assembled. It makes for a compelling scene in all the stories, the scientists and soldiers moving frantically around a modest ranch house as they build a bomb that will change the world. You can still walk in that house. You can duck in the short door and touch the adobe walls and see the wear in the floor where the chairs were scooted up to the dinner table each night. You can go to the Trinity site and, despite all the stories you've heard, you can stand in that house and know there were people there.

And if you do go, you'll likely see Tina Cordova there, at the gate, gathering with other downwinders at the edge of the missile range, holding protest signs, handing out educational pamphlets. They are not protesting the bomb itself, or the military, but protesting the fact that their stories have not been heard, that their suffering has never been acknowledged, that even though you won't see them on the big screen this summer, they were there. D

THE DOWNWINDERS

Late in 2021, as the downwinders geared up for another term of lobbying Congress, as Christopher Nolan announced he would be filming *Oppenheimer* in New Mexico, I returned with the photographer Reto Sterchi to another of the downwinders' annual vigils. There's an adage in journalism that it's important to put a face to the story. This summer the story of Trinity will have the faces of many movie stars attached to it, all representing the faces of scientists and generals and politicians involved in the Manhattan Project. But there are other stories in the wake of that first blast of the atomic age. These are some of their faces and some of their stories, in their own words.

—JOSHUA WHEELER

Henry Herrera

Henry was 11 years old and living in Tularosa when the bomb went off about 50 miles northwest of his home. He says he thought to himself, "The world is coming to an end." He watched the cloud of fallout move toward the mountains to the northeast, and then the dark cloud shifted south and came back toward Tularosa. He told his mother, "Aquí viene la bola pa'trás." (*The ball is coming back.*)

He remembers that the fallout "was on our roofs, our gardens, milk cows, rabbits, pigs, turkeys, and chickens . . . all we had was rainwater from the cistern and ditch water. All the debris from our roof was in our cistern after the first rainfall."

Henry first got cancer of the salivary gland. The radiation treatment caused osteoradionecrosis and damage to his carotid artery. His brother died of cancer. Both of his sisters are cancer survivors. Henry died in January 2022.

Irene Kowatch

Irene is Henry Herrera's younger sister and was eight years old when the bomb went off. She doesn't remember seeing the blast like Henry did. She figures she was probably asleep. But she remembers waking up to much shaking and things falling down. "I thought it was the whole world coming down," she says.

Irene and Henry were two of eight children in their family at the time of the Trinity test. Four of the siblings eventually developed cancer. Irene also lost her husband after bouts with skin cancer, prostate cancer, and lymphoma. Though he was not raised in Tularosa, he was in the military there, and she worries his frequent work near the Trinity site contributed to his death.

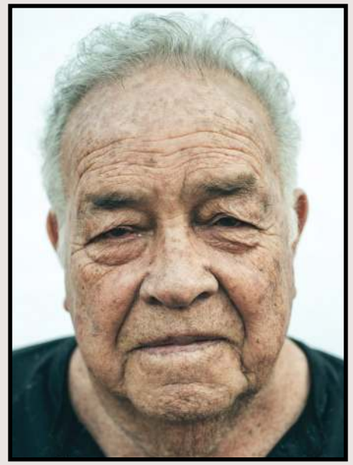
"I thought it was the whole world coming down."

Bernice Gutierrez

Bernice was only eight days old when the bomb went off less than 40 miles west from her home in Carrizozo. "I never heard a thing about the test," she says. "I knew the bomb had been tested there, but my family did not talk about it."

Her mother and brother were diagnosed with thyroid cancer in the 1990s. Her endocrinologist asked if her family had ever been exposed to radiation. Exposure to fallout from nuclear weapons is a proven risk factor for thyroid cancer and a common diagnosis after such exposure. Bernice's daughter also eventually developed thyroid cancer. On the advice of her doctor, Bernice had her thyroid gland removed in 2012.

In hopes of becoming eligible for RECA, Bernice set about researching her family's sickness from exposure to fallout. Her mother was one of 11 children, all born or raised in Carrizozo, 40 miles from the Trinity site. Each of those 11 siblings who had children have had at least one child diagnosed with cancer or brain tumors. In all, 20 members of her family from the area had different cancers, and six died from the illnesses. Twelve family members have had noncancerous radiation-related sickness such as thyroid disease. She says the research into her family's medical problems is time-consuming and traumatic. "It's almost like a full-time job fighting this battle. We've been totally ignored. Overlooked."



Raymond Najar

Raymond was seven years old at the time of the bomb test. He was living about 40 miles from the blast in the town of Carrizozo. "Looked like the sky was painted yellow," he says of seeing the explosion. "We was out in the yard that morning. . . . There was all kinds of people milling around out there. I just remember the air and sky was yellow. Like somebody poured a bucket of yellow paint in front of me."

He remembers how they would get milk a few times a week from their neighbor. He brought it over in an open bucket. "Everything was like that," he says, referring to consumption of local agriculture that would likely have been tainted by fallout. "We carried water from the railroad's roundhouse where they had an open reservoir. This was before plumbing. I carried two little buckets nearly every day."

Eventually Raymond's mother and all of his siblings developed thyroid problems. His mother had cancer, and Raymond is himself a cancer survivor. His wife, raised in nearby Tularosa, has lost her father and brother to lung and stomach cancer they believe is related to the fallout from Trinity.

Nora Follz

Nora was one day shy of two years old when the bomb went off about 50 miles west of her home in Nogal Canyon. She was one of four children at the time. Her father worked at Holloman Air Force Base. He brought home some groceries from his job at the commissary, but most of their produce came from a big garden they kept. "No telling what the vegetables had . . . after the ash and all that from the bomb."

In 1950 her family moved to Tularosa, where her brother died from leukemia at the age of five. But at that time, she says, they didn't think to connect an illness to the fallout because no one told them about radiation. "My oldest sister, Helen, was diagnosed with kidney cancer maybe 30 years ago. Another sister, Arcenia, died of multiple myeloma in 2006. Another sister, Virginia, was diagnosed with colon cancer about 15 years ago and then had breast cancer several years later."

All this illness, she says, made them question what caused it. And then when the true story of the fallout from Trinity started to get publicized as the plight of downwinders became mainstream news in the 1980s, everything made sense. "I've been part of the protests at the Trinity site. People honk or boo. I don't mind. I know they just don't understand. They've been lied to. Like us."

Rosemary Cordova

Rosemary was five months old when the bomb went off. Her family was living a few hundred miles from Trinity, in Pampa, Texas. She suggests this distance from the fallout is a reason she hasn't been diagnosed with cancer, though she is on medication for her thyroid. "But," Rosemary says, "cancer has plagued our family, and it is hard to remember each and every one of them."

Her grandfather had a sheep ranch only 50 miles northeast of the Trinity site, in a village called White Oaks. Though he had passed away in 1945, many of his nine children, Rosemary's aunts and uncles, still lived there at the time of the Trinity test. "Aunt Nellie died of stomach cancer. Aunt Lorena died of ovarian cancer. Uncle Juan Jay was diagnosed with breast cancer. Uncle George died in a prison camp in the Philippines during WWII . . . so that wasn't the bomb, but we still lost him to the war."

Rosemary's own mother, who moved them back near the family ranch at White Oaks around 1949, was diagnosed with brain cancer in 1964 and died 16 months later. "Cancer is like this branch of the family tree that keeps branching out," she says. "But it's not only genetics, . . . everyone around here dies of cancer. After the bomb . . . nobody was warned, 'Maybe don't eat the vegetables. Maybe don't drink the water.' It just makes me sick to think that we were guinea pigs."

Rosemary is still in Tularosa, where she lives with her son, who suffers from complications related to a brain tumor. "We are all doomed, us, our children, our grandchildren, and on, and on, and on. I pray that one day our government will do what should've been done long ago."

Tina Cordova

Tina's father, Anastacio, was four years old when the bomb went off 40 miles from his home in Tularosa. After bouts with prostate and tongue cancer, he eventually died when the cancer spread to his neck at age 71. Tina's mother, Rosalie, also battled mouth cancer.

Tina was diagnosed with thyroid cancer when she was 39. These illnesses and the nearly dozen other cancer diagnoses in her extended family living in Tularosa suggested they had suffered the same consequences from fallout as other Americans who lived near atomic weapons testing sites in Nevada and Utah. She founded the Tularosa Basin Downwinders Consortium with Fred Tyler in 2005. As a leader of this group, Tina has testified before Congress, spoken to countless classrooms and town halls, and been instrumental in changing the narrative around the fallout from the Trinity test. She's now fighting to pass legislation to compensate victims of the nuclear weapons industry in New Mexico.

"Cancer is like this branch of the family tree that keeps branching out."

Jolene Dalton-Maes

Jolene was only two years old and living on the corner of Vermont Avenue and 16th Street in Alamogordo when the bomb went off. Alamogordo is 70 miles southeast of the Trinity site, but there was never much talk of fallout in the town. "It was a government town," Jolene says. "Alamogordo and the Tularosa Basin were in the war long before the war," she says, referring to the region's history of military activity. She says the amount of money brought into the local economy by the military made it taboo for anyone in the area to criticize the bomb. In fact, the bomb was championed as the best thing that ever happened to Alamogordo when the city changed its nickname to "Atomic City."

Though Jolene doesn't remember much about the actual atom bomb test, she says her family certainly got produce from rural areas and all their milk from City Dairy, which serviced most of Alamogordo using cows from rural areas near Tularosa and Three Rivers, where substantial fallout was well documented.

"There was no [history of] cancer in my family," Jolene says, "and then my mother was 50 when she was diagnosed with breast cancer. Eventually she died from it at age 70. I had breast cancer. Was diagnosed at 56. Been in remission for 21 years. My younger sister had a rare ovarian cancer and died of that. My daughter is type 1 diabetic. She was nine when she was diagnosed. I'm convinced that my exposure to radiation helped cause that."

Stella Aguilar

Stella was 10 years old when the bomb exploded, living in the village of La Luz, 60 miles from the blast. Her father was off fighting the war, so it was just her mother caring for Stella and her three younger siblings. "The only thing I can remember is that . . . the house was shaking real funny. My mom jumped out of bed, and I followed her. We were looking out the kitchen window. The whole sky looked red. I thought it was a fire, but my mom said it was not a fire."

"We raised most of the vegetables on our land. We had a lot of fruit and chickens. The milk that we drank was from one of our neighbors that had a cow in La Luz."

Stella's mother and aunt, who also live in La Luz, both developed enlarged thyroids at a young age. Stella eventually had a tumor on her thyroid. Her daughter currently takes medication for her thyroid, and her grandson was born without any thyroid at all. Stella's sister, who was seven years old when the bomb went off, died from cancer, as did Stella's husband, who was raised in Tularosa and was 14 at the time of the test.

"The compensation money wouldn't have paid for even one month of healthcare for my husband . . . but if the government were to acknowledge or apologize . . . I think it would mean peace of mind, in a way."

Joshua Wheeler is from Alamogordo, New Mexico. He's written extensively about the legacy of the Trinity test, including in his book Acid West, *a collection of essays about the southern New Mexico border region. He lives in New Orleans and teaches at Louisiana State University.*

Reto Sterchi is a Swiss portrait and documentary photographer based in Los Angeles. He has a background in architecture and a BA in cinematography. His work has been published by Rolling Stone, *the* New York Times, Vice *magazine, and* National Geographic.

FROM THE MUSEUM

Is the plastic bag history?

TEXT BY ROGER TURNER
PHOTOGRAPHY BY ANNABEL PINKNEY

This is a plastic bag from a grocery store.

Is it a historical object? Yes! You can learn a lot about plastic—and the society that makes it—by observing a familiar object like this through the lens of history.

Is the era of the plastic bag over? Maybe. Governments around the world have banned single-use plastic bags. These efforts have reduced the consumption of bags like this one.

Are plastic bags going away? No. The material of this bag does not biodegrade. It slowly breaks apart, creating microplastic pollution that has been found in rivers, clouds, and even inside our bodies.

So is the plastic bag history? Yes, maybe, and no.

Strong
The plastics industry calls this a T-shirt bag, since it looks like a sleeveless, scoop-neck shirt. In 1959 Swedish engineer Sten Gustaf Thulin patented a system of folds and welds that make the bag strong.

Cheap
The design was first mass produced by Swedish plastics manufacturer Celloplast during the 1960s. The bag costs pennies to make and can carry more than 1,000 times its own weight.

Manufactured
Bill Seanor at Mobil Oil led the commercial development of the T-shirt bag in the 1970s. But Mobil was committed to low-density polyethylene used in cling wrap. Seanor and his colleagues established Vanguard Plastics to make high-density polyethylene bags that resist punctures and tears.

Dangerous
During the late 1950s dry cleaners began returning clothes in polyethylene sacks. But the clingy bags were soon linked to accidental deaths. Manufacturers responded with a national education campaign and thicker, less clingy bags. Today, five states and multiple national governments require printed warning labels on polyethylene bags.

Flimsy
When introduced to grocery stores in the 1970s, customers disliked how the bags fell over, unlike stiffer paper bags. And clerks licked their fingers to open the bags, disgusting some customers. In 1992 Sunoco patented the "self-opening polyethylene bag stack" that opens the next bag when one is removed.

Recyclable
Public concern about waste threatened the single-use plastic market. In 1988 the Plastics Industry Association developed the Resin Identification Code to promote plastic recycling. The numbers 1 to 7 correspond to different plastics. The #2HDPE on this bag means high-density polyethylene.

Disposable
During the 1990s plastic makers urged regulators to mandate the use of resin codes. This gave the impression that plastic was widely recycled. But today less than 10% of plastic is recycled.

Banned
Filmy plastics are challenging to recycle. Lightweight and aerodynamic, plastic bags flutter out of bins and tangle conveyor belts in recycling plants. In 2000 Mumbai, India, banned plastic bags. More recently, Philadelphia and other cities have restricted single-use bags, including paper bags not made with recycled material.

Enough?
Despite labels and store-based collection, plastic bags remain a major source of unrecycled waste. What do you see in the plastic bag's future?

How a Notorious Abortionist Built a Drug Empire

Desperate women, mistreated by the 19th century's medical establishment, risk black-market remedies and the wrath of moralizing thugs.

BY NANDINI SUBRAMANIAM

Anthony Comstock was never much fun.

During the Civil War, he watched with horror as his fellow soldiers drank, caroused, and otherwise debased themselves. Soon after the war he moved to New York City, where he encountered quacks, con artists, sex workers, and moral degenerates of all types.

Perhaps most troubling to Comstock was the sheer volume of young men engaging in debauchery—buying lurid dime novels, smoking tobacco, having rampant premarital sex. He sought refuge in the Young Men's Christian Association (YMCA), where he railed against the evils of pornography, bank fraud, gambling, infidelity, women's suffrage, and anything else he decreed a vice.

Five years of fighting for Christian morals with the YMCA established Comstock as a force within the anti-vice movement. In 1873 he created a vigilante organization dedicated to maintaining public decency. That same year he coauthored and convinced Congress to pass the Comstock Act, which prohibited the mailing of "obscene" materials, including pornography, sex aids, contraceptives, abortifacients, or any advertisement or correspondence referring to them. He was appointed special agent for the postmaster general, and from that position he set the machinery of the U.S. Mail against the malevolent forces he believed were corrupting the nation's youth.

To Comstock, there were few forces as dangerous as Madame Restell.

Restell, also known as Ann Lohman, was among New York's most enterprising women. She got her start in the 1830s, selling home remedies for unwanted pregnancies and other problems out of the city's disease- and crime-infested Five Points neighborhood. By the time Comstock set his sights on Restell, financial hardship was far behind her. From a brownstone mansion on Fifth Avenue, she catered to a disgraced and often wealthy clientele that stretched across the country. Like her affluent clients, she traveled in horse-drawn carriages, wore fine silk gowns, and oversaw a large household staff. Unlike most of her clients, she also managed land holdings and a business with satellite offices in Philadelphia and Boston.

Madame Restell had built her empire by addressing problems most doctors would not. It infuriated Comstock, and he was determined to tear that empire down.

On the frigid night of January 28, 1878, Comstock set out to finally do it, using a ploy he had turned to often. Posing as a customer, he rapped at Restell's mansion door and came face-to-face with his nemesis. Restell escorted her visitor to a basement room, where he requested "any article for the prevention of conception." After evading further questioning, Comstock was handed a small package of pills. Restell assured him they were effective 9 times out of 10, and if they were not, he should have his companion make an appointment for further intervention. He put $10 in her hand and walked out.

Two weeks later, on February 11, 1878, Comstock returned to Restell's doorstop with a search warrant and two police officers in tow. Officers found her home littered with pills, powders, pamphlets on reproductive health, and other "foul materials." She was ordered to police court, where a judge refused to accept bail, instead committing her to the city jail known as the Tombs in her old Five Points neighborhood.

On her release a few days later she flashed a defiant public posture, but she knew her prospects were grim. She had been tried and convicted twice before, even serving a year in prison on New York's Blackwell's Island. This time around, her punishment was bound to be far worse, the culmination of decades of public outrage and moral disgust.

Comstock and his allies had cast her as a fiend, demon, wretch, monster—the wickedest woman in New York. Her professional pursuits earned her comparisons to dissolute and powerful women of the distant past, including Valeria Messalina and Poppaea Sabina, ancient Romans vilified for their feminine wiles, promiscuity, and deceitfulness.

In March she was indicted for the possession and sale of improper drugs and medicines. She pled not guilty but was never tried.

"Madame Restell, otherwise known as Ann Lohman, cut her throat with a carving knife, and was found dead in her bathtub early yesterday morning," reported the *St. Johnsbury Caledonian* on April 5. "The estate which she has left is estimated to be worth half a million of dollars. She will be remembered as a noted abortionist."

The brutalities 19th-century women often faced at the hands of underqualified gynecologists drove them into the arms of practitioners like Madame Restell. The appeal of having someone who empathized and addressed women's health as a legitimate medical concern was powerful, but it would take until 1849 for the first woman to earn a medical degree in the United States. During a time when the medical field was reluctant to accept women into its ranks and saw women's bodies as naturally flawed, people like Ann Lohman—hidden behind fake names and fake credentials—found lucrative openings serving women outside the establishment.

Madame Restell's rise coincided with and, perhaps, was fueled by a period of constant flux in women's health care in the United States.

By the 1840s medicine had begun professionalizing, but gynecology was slow to follow. Specializing in gynecology was generally frowned on—it was dismissed as women's business and deemed unsuitable for dignified men. Childbirth was the realm of midwives, and midwives had no place in the medical field. As a result, men studying medicine were given sparse training on women's health and reproductive care. Those who chose to specialize in the field were often seen as perverse and lecherous, scoundrels preying on feeble women.

Despite this prejudice, some physicians still chose to specialize in women's disease, though the training they received was often rooted in speculation instead of tested observation. In 1848 Charles Delucena Meigs, chair of obstetrics and women's diseases at Jefferson Medical College, published *Females and Their Diseases*, an extensive chronicle of the fundamental sensitivity that predisposed women to illness. Meigs's explanations of disease were accepted as medical fact, and they contributed to a growing mass of misinformation around women's health and well-being. As new generations of physicians picked up Meigs's work and the work of those he influenced, women's health issues were ascribed to a fundamental and downright normal weakness.

Other forces in the medical establishment conspired to disempower women. The American Medical Association (AMA) was founded in 1847, and one of its first initiatives was to advocate for the criminalization of abortion nationwide, pushing midwives further to the sideline. At the same time, the AMA began cracking down on quacks peddling ineffective and often dangerous nostrums to the public. These actions were part of a larger objective to formalize medicine and create structured criteria around who could practice it. Members were deciding who counted as a real physician—a title that had been thrown around more casually before the 1850s.

In the years around the Civil War, a wave of social change rocked the United States and, in turn, challenged the medical establishment's treatment of women. Free love advocates rallied around the removal of state control in decisions concerning marriage, birth control, pregnancy, and relationships in general. Joining them were suffragists, who, in addition to calling for women's ability to vote, urged women to seize control of their health and well-being.

This threat to social and professional norms compelled doctors to use their medical authority to diminish the authority of the women who critiqued them. As Meigs and countless other doctors saw it, women were fundamentally weak and couldn't be trusted to vote, work, or learn.

In 1873 Edward Hammond Clarke, a physician and professor at Harvard Medical School, published *Sex in Education*, a book dedicated entirely to the "scientific" reasons why women shouldn't be allowed to attend his medical school. Clarke argued that women who studied like men risked "neuralgia, uterine disease, hysteria, and other derangements of the nervous system." Such women, he warned, would "give birth to a feeble race, not of women only, but of men as well."

Ann Lohman, also known as Madame Restell, from the *Days' Doings*, Sept. 1871.

LIBRARY OF CONGRESS

Another Civil War–era physician, Silas Weir Mitchell, became famous for his rest cure—a strict regimen of lying in bed, isolated from all social contact, with no activity of any sort in order to relieve neurological distress. Mitchell began experimenting with rest cures on traumatized veterans and soldiers in Philadelphia during the war. While many of these patients experienced relief, he soon began prescribing the treatment to the women who sought him out with complaints of unbearable pain. He attributed the severity of the pain to the biological weakness of their sex and believed switching up their scenery and diet would be sufficient to ease their distress.

Mitchell treated a long list of genteel patients, including writers Charlotte Perkins Gilman and Virginia Woolf, who referenced the lackluster results of his treatment in *The Yellow Wallpaper* and *Mrs. Dalloway*, respectively. Mitchell wrote his own elaborate novels, contributing to a booming genre of medical and fictional literature fixated on women's fragility. His stories, frequently based on his female clients, featured vacuous, invalid women in anguish—crucially, they were never actually diseased.

For the medical establishment, menstruation and the notion that women were unable to control the beginning or end of their cycle was seen as the root of female invalidity. So when all other interventions failed, the only solution that remained was to remove the very source of menstruation.

Enter Robert Battey. As gynecological surgery became its own specialized field in the second half of the 19th century, more and more physicians began prescribing invasive surgeries as remedies for a host of female illnesses. Battey implored other surgeons to consider the total removal of ovaries—even if the ovaries themselves were healthy—to cure everything from menstrual pains and irregularities to hysteria. His small-scale study into the efficacy of ovariotomy produced a mixed bag of successes, failures, and one death. (By the 1890s this frightening approach had extended to the uterus as well.)

"It is the great systemic revolution which occurs upon the final cessation of ovulation which I seek to effect and that such result follows upon the complete extirpation of the ovaries is, I think, not to be called in question," Battey wrote in 1876.

> Madame Restell's rise coincided with and, perhaps, was fueled by a period of constant flux in women's health care in the United States.

However, many women did push back against such medical narratives around their health.

Some began creating detailed educational pamphlets documenting the reproductive health issues they had experienced, how to identify them, and how they solved these problems without seeking a doctor. They exchanged herbal remedies they had learned over the years. This information was frequently shared in whispers between friends and neighbors and from mothers to daughters. But in some cases, women managed to disperse this knowledge on a much larger scale—by creating their own medical mail-order businesses.

"When the organs peculiar to woman are displaced or disordered, and pangs shoot through her like winged, piercing arrows or darting needle-points, man may study of all this in books, or question the sufferer as to the indescribable pain, but all must still remain to him a world of woe ever unknown and mysterious," noted *Lydia E. Pinkham's Private Textbook Upon Ailments Peculiar to Women*.

Born Ann Trow in 1811, Madame Restell was the only daughter of a laborer in Gloucestershire, England. She had seven brothers, started working as a maid at 15, and began selling contraceptives on the down-low sometime after the death of her first husband, Henry Summers, in 1833.

Just two years prior, Ann and Henry emigrated from England to New York. Henry was an alcoholic and barely made ends meet as a tailor. When he died, Lohman was left with an infant daughter to support and poor financial prospects. She took on work as a seamstress, but in their downtrodden neighborhood the competition among seamstresses was high and the pay was low. This was when she met William Evans, the neighborhood quack, who sold an assortment of proprietary pills, powders, and poultices with varying degrees of efficacy. Under his tutelage, she soon began discreetly selling her own contraceptives.

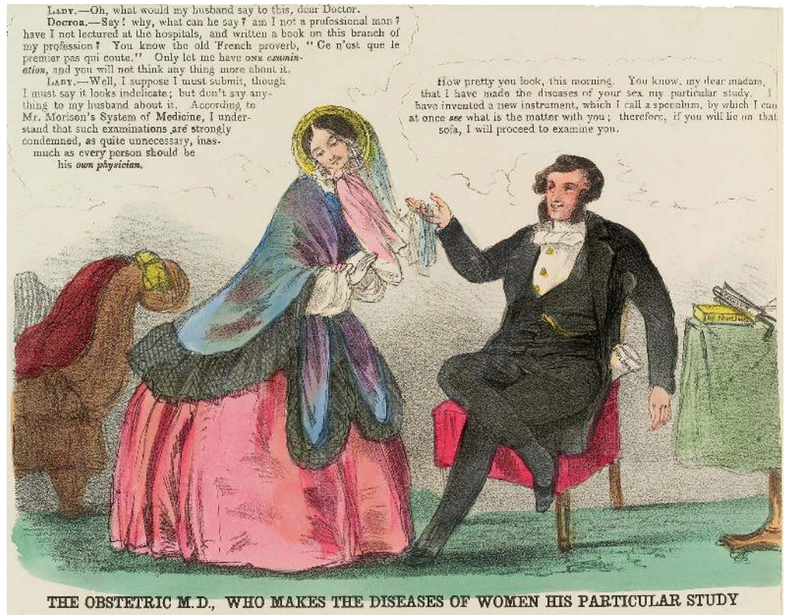
She met and married her second husband, Charles Lohman, a few years later, in 1836. He was a compositor for the *New York Herald* and a proponent of population control who had published tracts about contraception and family planning. Far from being horrified by her burgeoning enterprise, he encouraged it.

The story goes that he sent his new wife to France to study under her relative, and she returned equipped with a practitioner's understanding of midwifery and women's diseases. She adopted a pseudonym, Madame Restell, and launched a business selling pills, powders, and pamphlets on reproductive health out of a clinic in lower Manhattan.

The couple expanded their business, performing surgical abortions on a sliding scale or connecting women to surgeons who would perform the surgery. They also provided housing where unmarried women could wait out their pregnancies while arranging for their children to be adopted.

Throughout her decades of work, Restell experimented with new formulas for her powders and pills. During the 1830s her abortifacients used ergot of rye, which is taken from rye plants infected with the fungus *Claviceps purpurea*. The fungal spores create hard balls that contain the chemical alkaloids ergotoxine, ergotamine, and ergometrine.

But Madame Restell wasn't just pulling fungi off a plant and feeding it to her clients; she was adapting treatments that were based in the scientific consensus of the time. In 1813 a Massachusetts physician published his dissertation on the efficacy of ergot in activating uterine contraction during the second stage of labor.



A gynecologist tries to seduce a patient in a panel from *Morality of Modern Medicine-Mongers*, a satirical cartoon published by British quack James Morison, ca. 1852.

WELLCOME COLLECTION

Two decades later, the *Dispensatory of the United States of America* advised the consumption of 15 to 20 grains of ergot every 20 minutes to induce uterine contraction. Madame Restell was simply applying this science to earlier stages of pregnancy, which traditional physicians chose not to do. Ergot of rye had been used by midwives since the late 16th century, and obstetricians continued to use ergotmetrine, a drug derived from it, until the 1970s.

But like medicines used by her physician counterparts, Madame Restell's formulations could be dangerous, even fatal, when taken in the wrong amount. When consumed, ergometrine contracts the smooth muscles lining the uterus, which induces the contractions necessary for labor or miscarriage. But in excess, the other alkaloids found in ergot constrict arteries, slowing blood flow and causing gangrene of tissue and occasionally convulsions and hallucinations.

The fungus could just as likely induce nausea, vomiting, and diarrhea, purging it from the body before it had its intended effect. Fortunately for her customers, Madame Restell's business ran on the model that if her contraceptive powders and abortifacient pills didn't work, her clients could always come back to her for a surgical abortion.

By the 1840s Restell was offering liquid medicines that contained oil of tansy and spirit of turpentine. While turpentine can induce miscarriage, it can also cause internal bleeding, vomiting, brain damage, and death.

When Ann Lohman began selling contraceptives and abortifacients, laws around abortion were vague and difficult to enforce. In New York an 1829 ruling deemed abortions performed after "quickening," the onset of fetal movement, a felony. Abortions performed before quickening were a misdemeanor.

In 1841 one patient's deathbed confession that she had received an abortion from Madame Restell two years earlier led to a public trial against Lohman. She was found guilty, but her conviction was overturned when, after an appeal, the state supreme court deemed the deceased patient's confession inadmissible.

Innocent or guilty, the damage was done, and Restell's reputation as a filthy, villainous crook appealing to the baser morals of weak women was cemented. She was branded "a monster in human shape." Her practice continued, though under immense public scrutiny. It was only a matter of time before the police came knocking at her door again.

Sure enough, in 1847, Restell was brought to trial for providing an abortion a year earlier. Because quickening couldn't be established, she was found guilty of misdemeanor procurement and sentenced to a year on Blackwell's Island.

While she was sequestered, a book called *The Married Woman's Private Medical Companion* was published by a Dr. A. M. Mauriceau, a pseudonym for either Restell's husband or brother (or both, working together). Mauriceau was touted as a professor of women's diseases, and the book explained in detail the symptoms, causes, treatment, and prevention of uterine prolapse, menstrual pain, miscarriage, pregnancy, and infertility. Mauriceau, of course, worked right next to Madame Restell's office in New York and happened to be a purveyor of many similar mail-order contraceptives and abortifacients.

Some of the remedies on offer were quack solutions. For treating a case of infertility, Mauriceau recommended Morand's Elixir, which he presented as a miracle remedy.

"The lady being of the most pure and irreproachable character, it may well be supposed that it gave me the greatest confidence in recommending this truly wonderful 'Elixir,' in like cases," he wrote. "Indeed, I am convinced, that if the case is curable, 'Morand's Elixir' is infallible." He claimed it could also treat incontinence, gonorrhea, consumption, and night sweats for $5 a box (around $160 today).

According to Mauriceau, Morand's Elixir comprised "the most nourishing, strengthening, and invigorating fruits and plants of Italy," things that decidedly do not treat infertility. Although it's unclear what Morand's Elixir actually contained, other recommended remedies were provably dangerous.

Mauriceau's advice to "induce menstruation" involved the use of botanicals such as pennyroyal, tansy, and motherwort. The pennyroyal plant had been used for hundreds of years as a cooking herb, medicinal tea, and insecticide, but also as a method to induce miscarriage. The active chemical, pulegone, an oil extracted from the leaves and flowers of pennyroyal and other plants in the mint family, can quickly turn fatal.

For extreme cases of the "immoderate flow of the menses"—heavy menstrual periods, which Mauriceau alternatively called "hemorrhage"—the author suggested six grains of sugar of lead and one grain of opium divided into four parts and taken every three hours until symptoms ease. Lead (II) acetate, called sugar of lead for its slightly sweet taste, is, like most lead, quite toxic, though this wasn't known at the time. Opium similarly can lead to irregular menstrual periods (thereby technically controlling the menses), but it can also lead to heavier periods as well as infertility, not to mention addiction and all other manner of health problems.

But some remedies were legitimately successful and are still used to this day. Mauriceau's recommendations to take magnesia and peppermint water for heartburn are still medically sound, as is his advice to take mild doses of Epsom salt "if the bowels are confined."

"Anthony Comstock Shuddering at the Sight of an Unshelled Peanut," by Godfrey, *Rogue* magazine, July 1915.

Restell's husband and her brother Joseph bided their time selling the advice of Dr. A. M. Mauriceau during Restell's prison sentence. Upon her release a year later, Restell swore off all surgical abortions, focusing solely on her mail-order business and boarding house. But she never made her way back into society's good graces.

Doctors, journalists, and religious activists were vocal about their distaste for her and her business. She was blackmailed, threatened, shamed, harassed, and was always one misstep away from facing the unyielding horrors of the law.

"Madame Restell has in the basement of her establishment a large furnace, which an ill-behaved servant girl has had the temerity to say 'must be used for burning new born babies,'" alleged one newspaper.

"Lechery and lust paid tribute to her pretensions, and as business increased, so did the hopes, the avarice, and the audacity of this woman," a New York physician chastised.

Despite this vitriol, Madame Restell's extensive advertising campaigns pushed on in newspapers across the country. That fateful morning of her final arrest, she ran her regular advertisement for "Mme. Restell's sure remedies" on the front page of the *New York Herald*, offering free consultations at the home address from which she was plucked.

"Everybody is aware of her business and location," the *Helena Herald* remarked months after her death. "She cannot be accused of walking in darkness, or shrouding herself in mystery."

This was not entirely true. Given the social stigma around abortions and reproductive health in general, the ads were covert in how they directed women to her services and used oblique language, such as "obstructions" and "irregularities," as code for unwanted pregnancies. Her powders were said to resolve "too rapid [an] increase of family." The intended audience got the message. Restell received letters from across the country asking for medicines and advice. Her business became profitable so quickly that she had to warn patients against fraudulent copycats placing similar newspaper ads.

Indeed, dozens of other enterprising women, none in possession of professional medical accreditation, offered similar services. When doctors failed to take women's pain seriously or—worse—treated it with extreme, violent solutions, desperate women turned to entrepreneurs like Lohman instead.

The Comstock Act—with its new, vague definition of obscenity and prohibitions against the mailing of lewd materials—threatened the very existence of mail-order businesses like Restell's. Their advertisements were placed in newspapers and pamphlets distributed by the postal service. Buyers placed their orders using the mail, and products were shipped through it.

This focus on the postal service was only one step in Comstock's drawn-out campaign to eradicate sin and immorality in the American public, but it had an extraordinary chilling effect.

Just a few months before co-authoring the Comstock Act, he used his platform to found the New York Society for the Suppression of Vice (NYSSV). It began by preaching to young New Yorkers about the harm created by vice, but it quickly became a vigilante organization that conspired with local courts, lawyers, and police to enforce the Comstock Act.

He shut down literary magazines, raided publishers, and even arrested an art gallery owner for selling reproductions of Alexandre Cabanel's *The Birth of Venus*. Between its formation and 1906, the NYSSV seized and destroyed 78,391 pounds of books and sheet stock, 65,279 newspapers containing unlawful and obscene advertisements, and 10,321 boxes of abortive medicines.

At the time of Lohman's arrest in 1878, it was speculated that Comstock went after her so he could lay claim to a portion of her wealth after her conviction—a sort of reparations to the NYSSV, which was facing a depleted treasury and a decrease in donations. It was more likely a publicity stunt.

Over the course of 40 years Madame Restell had become the face of abortion in the United States and, by extension, women's interference in the male-dominated medical establishment. Taking her down would have been a blow to midwives, abortionists, mail-order entrepreneurs, and quacks across the nation.

The Comstock Act's challenges to these mail-order patent medicines did not, however, stifle demand. It was well-known that she "who becomes a mother, when unmarried . . . passes a fiery ordeal, from which she shrinks with terror. If she makes known her condition, a public disgrace awaits her: if she tries to conceal it, she is liable to imprisonment." Women continued seeking solutions to their unwanted pregnancies far away from gynecologists, even if the businesses they turned to were equally untrustworthy.

Madame Restell wasn't a doctor, though she referred to herself as a physician. This wasn't uncommon at the time she started her work. In the 1830s anyone could call themself a physician with no real credentials to show for it. But she and her husband took this lie further—they fabricated her entire trip to France to give her medical skills legitimacy, just as they fabricated A. M. Mauriceau, the doctor who steered patients in the direction of Madame Restell.

Comstock's motives in bringing her down had little to do with whether her services posed a danger to her patients. To most New Yorkers, Comstock was a religious fundamentalist and a fool, a man so wrapped up in his own self-mythology that he reportedly once shook his badge at a horse, yelling, "Don't you know who I am? I'm Anthony Comstock!" He was blind to his malignant narcissism, certain to the end of his life that he was a moral crusader, shrewdly rooting out evil.

For a decade after his death in 1915, the NYSSV channeled his fervor for seizing, raiding, burning, arresting, and just generally opposing all things "filthy." They squared up against birth control activists, gay bathhouses, pulp magazines, regular magazines, books, booksellers, and even Mae West, the star of the Broadway show *Sex*.

But as the 1920s and 1930s progressed, the NYSSV's attempts to uphold the Comstock Act started falling flat. Charges it brought were regularly dismissed, and it faced fines for making false arrests. The law was still enforced occasionally through the first half of the 20th century, but the religious outrage that Comstock embodied had receded.

A series of Supreme Court decisions in the 1960s and early 1970s put an effective stop to the enforcement of the Comstock Act, though the statute itself was never overturned. Other rulings legalized contraception and the ownership of obscene material. In 1973 *Roe v. Wade* established the constitutionally protected right to have an abortion.

The Comstock Act would lie dormant for the next 50 years, until the Supreme Court overturned *Roe v. Wade* in June 2022, leaving the legality of abortion up to the states. Within a year doctors and activists from the Alliance for Hippocratic Medicine in Texas began arguing that the Comstock Act made it illegal to distribute by mail mifepristone, a drug used to induce abortion and ensure safety during miscarriage.

The move was "part of this sort of stealth strategy to ban abortion nationwide," Drexel University law professor David Cohen told the *Texas Tribune* in March 2023. "If it's illegal nationally to mail . . . anything that is related to abortion, that would make it very difficult to operate an abortion clinic or to be an abortion provider."

In December 2023 the Supreme Court announced it would hear a case involving the Alliance for Hippocratic Medicine's attempts to ban mifepristone, making this the most consequential abortion judgment since the court overturned *Roe v. Wade*. The judges will issue their ruling by the end of June 2024.

Reproductive rights activists warn the ban on mailing mifepristone may be just the beginning. By limiting the safeguards around abortion, anti-abortion activists have inadvertently created space for do-it-yourself abortion businesses to roar back to life.

Already a volunteer network has sprung up, transporting abortion pills across the border from Mexico to Texas. It's a godsend for many women, but the circumstances are still imperfect. In 2022 the *New Yorker* relayed the experiences of a smuggler it called Anna and a pregnant eighth grader who sought Anna's help. The teen still seemed disquieted weeks after her abortion.

"In other states, or under another law system, her grandmother could have taken her to a sexual- and reproductive-health clinic, where they could have had a conversation with her, taught her about condoms, given her birth control, and sent her home feeling empowered with more information," Anna told the magazine. "Instead, she had to go to some random person's house. I'm sure they did not feel safe or comfortable here."

A trip to Madame Restell's mansion likely wasn't a 19th-century woman's preferred option either. But as medicine slipped further into the control of moral fundamentalists, a network of whispers and palmed remedies passed off as medical care was very often her only option. With the revival of reproductive care restrictions and Comstockian moral crusades, the return of latter-day Restells may not be far behind. D

Nandini Subramaniam was a gallery guide at the Institute.

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Chasing the Light

Come along with photographer Brandon Tauszik on a trip to the annual desert pyro party known as the Western Winter Blast.

“Where’s pyro gonna go? A lot of people say that drones and drone shows are going to take over. On television you’ve got computer-generated fires and all that sort. . . . Hopefully it never totally fizzles out.”

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