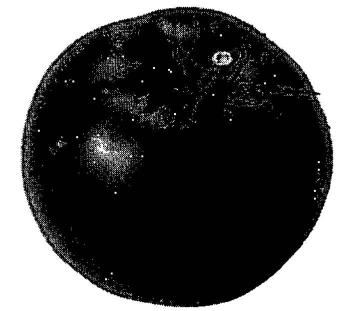
ROOTS



A Chilean soldier was guarding a lonely garrison in the Atacama Desert near the Peruvian border when the American tomato geneticist Roger Chetelat and his field research team arrived. The sentry obligingly provided what should have been straightforward directions to their destination: Follow the road beside the railroad tracks. As an afterthought, he quietly suggested that they be careful not to stray from the road, adding with a knowing nod, "land mines."

Chetelat, an athletic fifty-three-year-old, could be mistaken for a high school gym teacher. In fact he is the director of the prestigious C.M. Rick Tomato Genetics Resource Center at the University of California Davis, the world's foremost repository of wild tomato plants and their seeds. On that day in the desert, Chetelat and his group, which included scientists from the Universidad de Chile in Santiago, had been retracing a trail that had been cold for fifty years, its route filed away in the records of a Chilean herbarium. With luck—lots of it—the stale information might lead them to a few remote clumps of a wild tomato species called *Solanum chilense*. If the team was successful, seeds from those plants, which had never before been collected in that area, would become a valuable addition to the center's collection.

But that was a big "if." First, there were questions concerning the accuracy of the pre-GPS location, given as simply "kilometer 106-108" on the cog railway that switch-backed through the Andes between Chile's port city Arica and La Paz, Bolivia. The notation had been scrawled in the journal of a British collector sometime in the 1950s. Even if the directions were valid, a lot can happen in a half-century to an isolated cluster of plants. Roads get built. Gas pipelines go through. Settlements grow. Fields expand. Animals browse. Facing the distinct possibility that they were on botany's version of the wild goose chase, the researchers had been driving across the desert since dawn and had yet to see anything resembling a wild tomato.

The Atacama Desert makes up the southernmost part of the geographic range of modern tomatoes' wild ancestors, which still grow in parts of western Chile, Peru, and Ecuador (and the Galapagos Islands, home to two errant species). It is a testament to the adaptability of the tomato clan that its members can survive in the Atacama, one of the most inhospitable places on earth. The gravelly, boulder-strewn landscape is fifty times as dry as California's Death Valley. Some parts have not received a drop of rainfall in recorded history. Chetelat has driven across its surface for an entire day without seeing a single living thing. Most of the plants that survive there are low and scrubby and, during the driest months, brown and to all appearances, dead.

Chetelat was further discouraged when the road they had been told to follow diverged from the rail line several kilometers before they reached their goal. Frustrated but still determined, the driver veered onto the tracks, which were still occasionally used, and bounced and jolted along until that became too uncomfortable. Still well short of the marker, the scientists set out on foot, even though it was getting late in the day and no one wanted to bivouac in a semi-militarized no-man's-land. It didn't help that they had not seen a tomato. Until they

arrived at kilometer 108, that is. There, just as described, with yellow flowers glowing in the afternoon light, were *S. chilense*, descendants of the plants seen by the 1950s collector. The researchers' reward for a long, uncomfortable session in the field was a handful of seeds not much bigger than grains of sand. Chetelat considered it a good day.

If you enjoy tomatoes, it was a good day for you, too. Their field work in many ways echoes the expeditions of those quirky Victorian naturalists who scoured the globe to add botanical curiosities to their collections. But were it not for the efforts of Chetelat and his predecessors and colleagues at the Rick Center to find and conserve all seventeen species that make up the tomato family, there is a very real possibility that tomato production as we know it today would not exist.

Of all the species that played a part in the great Columbian Exchange—the widespread mingling of plants, animals, and disease organisms between the Eastern and Western hemispheres following the establishment of Spanish colonies in the New World—the tomato surely would have topped the list as the least likely to succeed, never mind to become one of our favorite vegetables. Botanists think that the modern tomato's immediate predecessor is a species called *S. pimpinellifolium* that still grows wild in the coastal deserts and Andean foothills of Ecuador and northern Peru. Inauspicious and easily overlooked, S. *pimpinellifolium* fruits are the size of large garden peas. They are red when ripe and taste like tomatoes, but picking a handful of the diminutive fruits as a snack would take several minutes. Gathering enough for a salad or salsa wouldn't be worth anybody's effort.

Were it not for a few random genetic mutations—mere flukes—chances are that pre-Columbian Americans would never have bothered to domesticate the plants that bore those tiny red berries. Chetelat speculates that some unknown forager or farmer noticed an unusual *S. pimpinellifolium* plant, one that produced larger-than-usual fruits. For reasons that are lost to archeologists, these "deformed" plants were not domesticated in the areas where they grew wild. Researchers have found no evidence of tomatoes depicted on the pottery and tapestries made by natives of what is now northern Peru, which were often elaborately adorned by images of foods important to their diet. Instead, tomatoes were domesticated by Mayan or Mesoamerican farmers somewhere in what is now southern Mexico or northern Central America, more than one thousand miles from the home range of their wild kin. The earliest cultivated tomatoes were of the variety *S. cerasiforme*. Now considered a subspecies of *S. lycopersicum* (the scientific name for domestic tomatoes), *S. cerasiforme* looked and tasted like the cherry tomatoes that are sold in plastic clamshell containers in produce sections and scattered atop fast food salads today. In addition to being small-fruited, *S. cerasiforme* produced long, sprawling vines familiar to any home gardener who has tried to rein in the rampant, weedy growth of varieties like Matt's Wild Cherry, a commonly available type much like the first tomatoes to be cultivated. If you cut any cherry tomato in half, you will notice that it has only two compartments filled with seeds. Some of the early *S. cerasiformes* developed mutations that caused them to produce more than two seed cells. Another mutant strain had a gene that dramatically increased the size of its fruits. Selecting plants that produced larger fruits, or fruits with differing shapes and colors, pre-Columbian farmers created tomatoes that resembled most of the varieties available today. When Hernán Cortés conquered the Aztec city of Tenochtitlan (now Mexico City) in 1521, tomatoes had become an important part of the indigenous diet. Aztec writings even include a dish calling for hot peppers, salt, and *tomatls*—the original recipe for salsa. The Aztecs also had another recipe that required tomatoes, according to the conquistador Bernal Díaz del Castillo. After his troops captured one city, he wrote that the defenders had already prepared a large pot of salt, peppers, and tomatoes in anticipation that victory would provide them with the final ingredient—the flesh of the invading Spaniards.

Spanish explorers wasted no time introducing the beguiling New World fruit to Europe, where it soon established itself. By 1544, just a

little more than two decades after their "discovery," the Italian herbalist Pietro Andrea Matthioli published the earliest European reference to tomatoes, calling them *mala aurea*, golden apples. A decade later, Leonhart Fuchs, a German doctor, produced the first known illustration of tomatoes, a colored woodcut showing that the fruit not only arrived in Europe with golden exteriors, as Matthioli's name suggested, but also red skins and in many different shapes and sizes. At first, Europeans viewed tomatoes as merely decorative, but soon they began using them as medicines, most often to treat eye ailments. Introduced to France, tomatoes were called *pommes d'amour* (literally "love apples," but the designation might have been a corruption of the Spanish name, *pome dei Moro*, or Moor's apple). By the end of the sixteenth century, tomatoes had finally entered the diet of southern Europeans. Writing in his 1597 *Herball*, the British barber-surgeon John Gerard reported that "love apples" were eaten in boiled form along with "pepper, salt, and oile" as a sauce, although his assessment of the result would not have made his countrymen salivate in envy of Italian gourmands. "They yield very little nourishment to the bodie, and the same naught and corrupt," Gerard wrote, adding that tomatoes were "of rank and stinking savor." Apparently the Italians disagreed. In 1692 the first cookbook mentioning tomatoes was published in Naples, and *pomodori* were on their way to becoming the signature ingredient of southern Italian cuisine. Although they eschewed eating the "rank and stinking" tomato, the British did begin to use it, not for its culinary merits, but for its curative powers over such maladies as headaches, blockages of the bladder, gout, sciatica, running sores, hot tumors upon the eyes, and vapors in women. The first Britons to dine on these misunderstood love apples were Jews of Portuguese and Spanish ancestry in the mid-1700s.

In the United States, colonists called the love apple by its Mexican name, *tomate*, and in the years following the Revolutionary War grew it and incorporated it widely into their cooking, although some

Americans viewed the fruit as poisonous. They found other uses for it, too. One writer recommended putting fresh vines under blankets as a way to control bedbugs. In the early 1800s, patent medicine hucksters began bottling tomato extract as an elixir, advertising that it would cure ills ranging from constipation to chronic cough to the common cold. Their boosterism sparked a national tomato craze, enabling farmers near big cities to make fortunes. Being prolific, tomatoes provided filling food for hungry soldiers. And being high in acid, they lent themselves to the new technology of risk-free canning. The Union Army left a trail of empty tomato cans in the wake of its campaigns. After the war, the veterans' appetite remained unabated. Expensive, out-of-season fresh tomatoes became status symbols. Tomatoes even made it all the way to the Supreme Court. To protect American farmers from competition from Caribbean growers of fresh winter tomatoes under the Tariff Act of March 3, 1883, the justices in 1893 rewrote the dictionary and decreed that tomatoes were vegetables (they are in fact fruits).

Tomatoes' near-universal popularity in North American kitchens and gardens today can be traced back to the efforts of one man, Alexander W. Livingston, who was born in 1821 in Reynoldsville, Ohio, just outside Columbus. His career as one of the greatest tomato breeders in history got off to an inauspicious start. In his autobiography, *Livingston and the Tomato*, he recalls: "Well do I remember the first tomato I ever saw. I was ten years old, and was running down one of those old-fashioned lanes, on either side of which was the high rail fence, then so familiar to all Ohio people. Its rosy cheeks lighted up one of these fence-corners; and arrested my youthful attention. I quickly gathered a few of them in my hands and took them to my mother to ask, 'What they were?' As soon as she saw me with them she cried out, 'You must not eat them, my child. They must be poison for even the hogs will not eat them. . . . You may go and put them on the mantle, they are only fit to be seen for their beauty.'"

It's a good thing for tomato lovers that young Alexander ignored his mother's advice. By 1842, Livingston began working for a local seed grower. A decade later he had purchased his own land and turned his attention to developing a tomato that was distinctly better than the gnarly, hollow, and dry fruits that were the norm in the middle of the nineteenth century. After more than a decade of following the accepted wisdom of the era—saving the seeds from the largest and most promising fruits each year and replanting them the next—Livingston revolutionized crop development. Instead of looking at fruits, he sought out whole plants that had desirable traits and crossbred them with varieties that had complementary qualities. He came across a plant that bore large quantities of perfectly round fruits. Unfortunately, they were small, so he crossed and recrossed those plants with large-fruited varieties until, five years after spotting that first smooth-fruited plant in his field, he perfected a variety he called the Paragon.

In addition to being a talented botanist, Livingston had a gift for writing unabashedly hyperbolic advertising copy—a key job requirement for successful seed catalog copywriters to this day. The Paragon "was the first perfectly and uniformly smooth tomato ever introduced to the American public, or, so far as I have ever learned, the first introduced to the world." Giving himself credit where it was due, he wrote, "With these, tomato culture began at once to be one of the great enterprises of this country."

Paragon was just the beginning. Livingston himself went on to personally breed a dozen more successful tomatoes, and by 1937 the U.S. Department of Agriculture estimated that half of the tomato varieties in the country owed a genetic debt to Livingston's early discoveries. It's a testament to the nineteenth-century plant breeder's skills that Paragons can still be found in seed catalogs today. I usually put a few in my garden each summer, my way of paying homage to the Great Man. They may not be the best tomato of the season, nor the most prolific, but, as advertised, Paragons are smooth, round, and juicy. If they have anything to apologize for 140 years after their debut, it's that by being consistently prolific and uniform, they gave rise to the fresh tomato industry whose dubious benefits we reap today.

Florida was a late comer to the commercial tomato game. They were grown there as early as 1870 by two farmers named Parry and Wilson in Alachua in the northern part of the state. Two years later, E. S. Blund was harvesting tomatoes on Sanibel Island in southwest Florida. But Joel Hendrix, a shopkeeper and owner of a commercial steamship dock, as well as a six-acre farm in the settlement of Palmetto, established the commercial model that the Florida tomato industry has followed ever since. On January 6, 1880, Hendrix wrote a letter outlining a business plan that involved exporting green tomatoes from Florida that would ripen on their way to northern markets. He then demonstrated that it could be done successfully by shipping a cargo of the unripe fruit from his field in Manatee County (just south of Tampa and still an important tomato growing area) to New York City. No record remains describing the taste or condition of Hendrix's fruits, which in that era would have endured a bouncy wagon ride over rutted sand trails before being loaded onto one or more steamships and rail cars for the long, often rough journey north. But fresh fruits and vegetables of any sort were rarities in the North at that time, and the Yankees eagerly gobbled up Hendrix's out-of-season tomatoes. Establishing another policy that the Florida industry still follows, Hendrix priced his product inexpensively at a level that the average winter-weary New Yorker could afford. Green, cheap, and off-season continue to be the three mercantile legs upon which Florida's tomato industry stands.

Other farmers followed Hendrix's lead. By 1890, a decade after that first shipment, there were 214 acres of tomatoes growing in Manatee County, according to the U.S. Department of Agriculture. The industry never looked back. Aided by the arrival of the railroad in 1884, land under tomato production in Florida increased to 6,675

acres by 1900, in no small part because the crop thrived in the virgin, disease-free soil. Those carefree days ended abruptly in 1903 when an outbreak of fusarium wilt wiped out tomato plantings. But with plenty of vacant land to exploit, growers simply abandoned diseased fields and cleared new ones, slowly pushing inland from the coast. By 1930, there were twenty-nine thousand acres of tomatoes growing in the Sunshine State.

That was around the time that scientists perfected commercial applications for artificially exposing unripe fruits and vegetables to ethylene, a gas that plants produce naturally as a final step in maturing their fruits. Writing in a 1931 issue of *Industrial and Engineering Chemistry*, E. F. Kohman, a researcher with the National Canners Association, observed that if gassed with ethylene, tomatoes could be picked before they were fully ripened and therefore would withstand handling better than their nongassed counterparts, although he acknowledged: "It should be clearly understood that by no known method of ripening except on the vine can a tomato be produced equal in quality to a tomato fully ripened on the vine." Although Florida farmers wholeheartedly embraced the idea of artificially "degreening" their unripe crops, Kohman's concerns about quality were quickly forgotten.

The person most responsible for ushering in the boom years of the Florida tomato industry was an unsuccessful Cuban lawyer named Fidel Castro. Until the embargo of the early 1960s, Florida tomato farmers faced stiff competition from produce grown on the balmy island to the south. But with a stroke of President Kennedy's pen in 1962, no more Cuban tomatoes could be had in the United States. Florida wasted no time stepping into the void. In 1960 the state grew about 450 million pounds of tomatoes a year. Within five years, the harvest had increased by 60 percent to 720 million pounds; revenues soared seventeenfold from $47 million in 1960 to over $800 million by the 1990s. Tomatoes had become big business.

Max Lipman, a European Jewish immigrant who initially settled in New York City, exemplifies this period of expansion. In 1942, he moved to Florida, where he hoped to make a success with a small vegetable wholesale business, buying from local farmers and shipping their produce to northern customers. Within ten years, he had purchased his own land near Immokalee in the southwestern part of the state and was joined in the business by his three sons and three sons-in-law. Playing off the family name, they called their business Six L's Packing Company. Four generations later, the company is still controlled by the Lipman family. It grows, packs, and ships fifteen million twenty-five-pound boxes of tomatoes a year from a sprawling warehouselike facility on the outskirts of Immokalee. Six L's has captured 12 percent of the Florida tomato market, making it the largest of the dozen or so big growers that now raise and ship virtually all Florida tomatoes. Other large companies in the state, like Pacific Tomato Growers, Procacci Brothers Sales, East Coast Growers and Packers, and DiMare Fresh, share almost identical corporate histories to that of Six L's. Launched by ambitious first- or second-generation immigrants, often from small stalls or push carts in northeastern cities such as Boston, New York, and Philadelphia, they expanded rapidly in the second half of the 1900s to become huge companies that, even after several generations, are still run by descendants of the founding family member.

Today's tomatoes may be big, juicy, and smooth skinned, but on their circuitous journey from the arid hillsides and rocky canyons of coastal South America to our dinner tables, they lost many of the genetic traits that were once critical to their survival. The pea-size *S. pimpinellifolium* and the other wild relatives of modern tomatoes that Chetelat and his team seek out and attempt to preserve are tough, versatile organisms that have evolved disease resistance and tolerance to extreme environmental conditions—genetic traits that researchers can incorporate into cultivated tomatoes, a feeble, inbred lot that, like

some royal families and certain overpopularized dog breeds, need all the genetic help they can get.

Drop by nearly any farmers' market on a summer Saturday, and displays of cultivated tomatoes all but scream out the word *diversity*. Small cherry tomatoes, grape tomatoes, pear-shaped salad tomatoes, soft ball–size beefsteak tomatoes the color of fire trucks, plum tomatoes, tomatoes that are ribbed like pumpkins, tomatoes that are as perfectly spherical as a billiard ball, tomatoes that are lobed and lumpy, tomatoes that mature ninety days after being transplanted, tomatoes that require only sixty days, tomatoes that when ripe are red, pink, orange, yellow, purple, green, or any combination thereof. But all that variety is literally only skin deep. Botanists have but one name for all those oddball cultivated tomatoes: *S. lycopersicum*. "Most of the variation you are seeing is from a few genes that control color, shape, and size," said Chetelat. "Other than that, there is very little genetic variation."

The mutant plants that the Mayans domesticated were literally cut off from their ancestral roots, living in isolation more than one thousand miles away from other plants of the same species. As early farmers saved seeds from offspring of the original few plants from year to year, the population became increasingly inbred, a process geneticists call a "bottleneck effect." Chetelat draws an example from human migration to explain this phenomenon. "Imagine a handful of people settling a new continent. They represent only a small part of the genetic diversity that was within the continent they left behind. If there's no more migration, then the diversity is even further reduced by inbreeding." Tomatoes went through a series of such bottlenecks in their prehistoric journey from Peru to Mexico, losing genetic diversity each time, and then went through another series of bottlenecks when conquistadores took them from Mexico to Europe.

The problem of inbreeding is exacerbated in cultivated tomatoes because, unlike their wild brethren who must receive pollen from another plant to produce fertile seeds, they are self-pollinated.

A single domesticated plant can "breed" with itself, and the resulting seeds produce offspring that are basically clones, identical to the parent plant. Not going to the bother of connecting with a mate is a rapid, surefire way to reproduce, but it further decreases genetic diversity, producing generation after generation of plants with the same traits—or lack of them. As a result, all the varieties of cultivated tomatoes that have ever been bred contain less than 5 percent of the genetic material in the overall tomato gene pool. "They seem diverse," said Chetelat. "But at a DNA level they are very similar. If it wasn't for the genes of these wild species, you wouldn't be able to grow tomatoes in a lot of areas. I don't think there is a cultivated plant for which the wild relatives have been more critical."

I met Chetelat and some of the offspring of those Chilean *S. chilense* one cool, misty January afternoon inside a greenhouse belonging to the Rick Center at the University of California Davis, which is named after its founder, the late Charles M. Rick Jr. Charlie, as his associates called him, worked at the facility until shortly before his death in 2002 at age eighty-seven. He was a legendary plant science professor, a pioneer in discovering and preserving the seventeen species of wild tomatoes, and the world's foremost authority on the genetics and evolution of the tomato.

Born in Reading, Pennsylvania, Rick developed a love of horticulture by working in apple orchards as a boy. After getting a PhD from Harvard, he moved to Davis, where he became a professor of plant genetics. Receiving a Guggenheim Fellowship in 1948, he spent a year in Peru, the first of fifteen field trips he would eventually make to South America to collect seven hundred samples of seeds and other genetic material from populations of wild relatives of tomatoes, many of which have since gone extinct in their native habitat and live on today in the collections of the Rick Center. He combined a photographic memory and an indefatigable work ethic with a puckish character and a natural flair for storytelling. Associates say he possessed attributes of Charles Darwin, Mark Twain, and Indiana Jones.

Until the end of his life, he was an easily recognized character on the U. C. Davis campus, mounted on an ancient, thick-tired bicycle with his full white beard, granny glasses, and floppy cotton fishing hats.

More than anything, however, Rick was big hearted and generous in an academic field where professional relationships are often marked by secrecy and competitiveness. It was Rick who instituted the center's policy of giving seeds away. The Rick Center acts like a lending library, nurturing and preserving its 3,600-specimen collection but also making it readily available to scholars and plant breeders worldwide who want to "check out" seeds for their own experiments.

Today, those seeds are kept in a vault that resembles a restaurant's walk-in refrigerator. Chetelat ushered me inside. A roaring compressor kept the air at a chilly forty-five degrees and the humidity at a dry 25 percent. The space was jammed with shelves holding trays that were filled with small manila envelopes containing seeds. Periodically, supplies in the vault are augmented by seeds from plants grown in a greenhouse like the one where I met Chetelat.

Had he not been my guide, I would never have recognized the plants that surrounded us in the Davis greenhouse as being even remotely related to the plump, red tomatoes in the produce section. These varieties were perennials with solid, semiwoody stems, not the one-season wonders of my garden. Some plants were almost mosslike, creeping along the soil like thyme. One, called *S. ochranthum*, climbed until it touched the glass roof twelve feet overhead and then doubled back toward the floor. Chetelat told me that its vines can grow fifty feet tall, completely covering small barns and outbuildings in its native Peru.

Foliage came in all shapes, sizes, textures. Some of the flowers were odorless, but others perfumed the air with the aromas of jasmine and honey. The round, scalloped leaves of *S. pennielli* were covered with what seemed like a bad infestation of white, gnat-size flies. When I touched a leaf, my finger stuck to its surface, a natural version of flypaper that entraps would-be pests (and left me with gummy fingertips). Another plant, *S. juglandifolium*, bore leaves that were tough, wrinkled, and leathery looking, as if they had fallen from an ancient walnut tree. When rubbed, they gave off piney notes. *S. sitiens* could have been mistaken for Italian parsley, except its leaves were stiff and covered in a waxy substance to prevent water loss. When particularly dry, they fold themselves in half to preserve moisture. The plant across the aisle from the parsley look-alike had leaves covered in fine hairs like those on a prepubescent boy's upper lip. Crushed between my fingers, the leaves exuded a powerful piney smell mingled with hints of celery. The fruits hanging from the vines seemed like a haphazard collection of miniature marbles, the biggest not much larger than my little fingernail. They came in an array of colors: black, yellow, purple, green with white stripes, green with a purplish blush. One plant, *S. habrochaites*, a native of the high Andes, bore tiny, furry fruits that smelled like Vicks VapoRub. Chetelat said that the red color we so closely associate with tomatoes was a one-time genetic event carried by a single member of the tomato family, *S. pimpinellifolium*.

Overcome by all this tomato diversity, I plucked a yellowish-green fruit from a plant Chetelat identified as *S. arcanum*. I squeezed it, and a slimy green substance containing dozens of seeds no bigger than pinheads squirted into my palm. I slurped it. The distinct taste of soap assaulted my mouth, followed immediately by a dry, burning bitterness that lasted . . . and lasted. "You're the first visitor here who has been brave enough to eat one of those things," Chetelat said nonchalantly. "Hopefully you won't die." Could this inedible fruit really be a close relative of a plant central to culinary cultures around the world? The zesty yet sweet base of countless soups, sauces, salsas, and condiments? A treat savored unadorned and out of hand on a warm midsummer afternoon?

But the Rick collection is not really about taste. Domestic tomatoes had virtually no innate resistance to common tomato diseases and pests until breeders began crossing them with wild species in

the 1940s. "They were fairly a defenseless lot," explained Chetelat. Wild tomatoes, on the other hand, are more robust: "We know of at least forty-four pathogens for which resistance has been found in wild species." Commercial seed companies have bred traits into domestic varieties to combat about half of those pests and diseases. If you buy from a seed catalog, the maladies that a tomato resists are usually represented by a series of letters following the name. These include such notorious plant killers as stem canker, spotted wilt virus, fusarium wilt (the disease that wiped out tomatoes in Florida in the early 1900s), grey leaf spot, nematodes (microscopic worms), tobacco mosaic, and verticillium wilt. "Most of the efforts so far have been focused on disease," said Chetelat. "It's been the first target, because disease resistance often determines whether or not you can grow a tomato, period. But secondly, on a genetic basis, disease resistances tend to be simply inherited. For the most part, you are talking about single, dominant genes that are fairly easy for geneticists and breeders to work with, whereas breeding for something like increased yield or improved flavor involves multiple genes, so it is harder for researchers to get a handle on those issues. Disease resistance is the best justification for this facility."

Chetelat pointed to an example from his own backyard tomato patch. "I happen to live in an area where the soil is infested with nematodes, which are so much of a problem that I cannot grow heirlooms. They immediately get sick, develop root galls, and collapse before I get much fruit. So I grow nematode-resistant hybrids. That resistance comes from a wild species called *S. peruvianum*. It's native to Peru and bears small green fruits that are inedible—they'd probably make you sick to your stomach. But it is resistant to nematodes. That resistance has been bred into hybrids."

And more potential remains untapped. Any grower in the Northeast in the summer of 2009 who had to dig up and either bury or burn every wilted, blackened tomato vine in the garden is familiar with the ravages of *Phytophthora*, commonly known as late blight, the same mold that killed the potato crop in Ireland in the 1840s, causing the Great Famine. Chetelat told me that there are wild species that are quite tolerant to the disease waiting for the attention of a future plant breeder. Currently, the center is working with researchers from India who hope to incorporate from a wild species into domesticated varieties resistance to tomato yellow-leaf curl virus, a devastating disease that limits tomato production around the world.

Wild tomatoes might even help fight disease in humans. Chetelat and his associates have conducted experiments showing that it is feasible to boost the levels of ascorbic acid, lycopene, beta-carotene, and other healthful antioxidants by introducing genes from wild tomatoes into domestic varieties. Because tomatoes and tomato products are a major source of nutrients worldwide, higher antioxidant levels could have enormous health benefits.

The possibilities of using wild traits to improve cultivated tomatoes seem almost limitless. Some wild species grow at chilly altitudes, thirty-five hundred meters up in the Andes, tolerating low temperatures that would cause other tomatoes to shrivel and die. Others thrive in humid rainforests. A few can eke out an existence in the desert. They have adapted to scant rain and intense heat, potentially useful for commercial crops in warm, dry areas like California's Central Valley during a time of irregular rainfall and global warming. With advances in the technologies of working with DNA, new areas are opening up for breeders. Better methods will allow scientists to routinely address more complex traits, such as the elusive matter of taste, which is controlled by multiple genes. Chetelat said he viewed it as a time of opportunity.

But, unfortunately, time could be running out for the wild populations upon which future discoveries may depend. Modern agricultural practices and urban sprawl eliminate habitat for wild tomatoes. Herds of goats, llamas, alpacas, and other domestic animals eat and trample them. Even though the Rick Center can produce seed from previously gathered wild specimens, thereby maintaining genetic

lines, Chetelat insisted that collections preserved by humans, however carefully, are no substitute for what he calls "in situ" plants, meaning ones that grow in their native environments without human interference. The most obvious difference between the two is that Chetelat and his team grow their wild tomatoes artificially in greenhouses with adequate water, optimum lighting, and no competition. Pests and diseases are chemically controlled. "You're really changing the environment," he said. "And that causes genetic shifts from one generation to the next. It's artificial selection." There are other potential problems. If growers are not careful, pollen can flow between two distinct populations of a species being raised in the same greenhouse. A harried technician might simply mislabel seeds or mishandle them, allowing one variety to mingle with another. "We wouldn't have a problem if we could store seeds forever and if we had an infinite number of seeds to fulfill researchers' requests," said Chetelat. "Of course, that's not the way it works."

So he and his associates must still pack their collection equipment and head back out into the field. Their latest trip to northern Peru in 2009 illustrated the severity of the conservation challenge. When Rick and others had visited the area decades earlier, they made detailed records of where they observed native populations. Chetelat intended to return to the same sites to reexamine those populations.

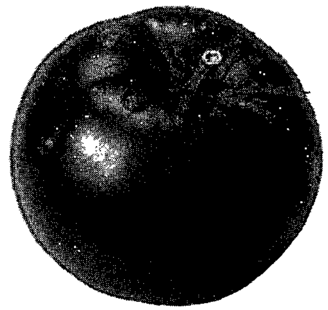
Since the mid 1990s, intensive sugarcane agriculture has come to low-lying valleys north of Lima, vast monoculture fields carpeting the valley floors from one mountain range to the other. Chetelat talked to farm supervisors and laborers who formerly nibbled the ubiquitous little tomatoes as snacks, as we might pick a few wild blackberries in the fencerow beside a pasture. They told him that when the sugarcane came, accompanied by the usual herbicides and other agricultural chemicals, the tomatoes disappeared.

Everywhere Chetelat went, the story was the same. It was only when his group ventured higher into the mountain valleys, above one thousand meters, where conditions were too rough and available spaces too small for sugar estates, that they began to find wild tomatoes growing in rocky areas and out of cracks in fieldstone walls. "That area is the center of diversity for one of the immediate ancestors of the cultivated tomato," he said. "And now most of those populations are gone."

In an effort to evaluate the situation more thoroughly, Chetelat is hoping to return to the region sometime in the next few years. Despite the modern advances in genetics and DNA mapping, this expedition will be more in the spirit of early plant collectors like Dr. Rick, the center's founder. His goal is to secure funding from the National Science Foundation to work closely with a team of Peruvian graduate students. Like the old-time botanists, they are going to scour the landscape and count individual plants at differing elevations. After a thorough, scientific evaluation of the remaining wild populations, he hopes to convince officials to take steps to preserve these tomatoes before they, too, are bulldozed or blasted with herbicide.

After we left the balmy greenhouse and stepped back into the chilly mist, Chetelat paused before locking the door. Nodding to the vines behind the glass, he said pointedly, "There may be a chance that fifty years from now, someone will find something really important in something that's growing in there. That is what this is all about."

A TOMATO GROWS IN FLORIDA

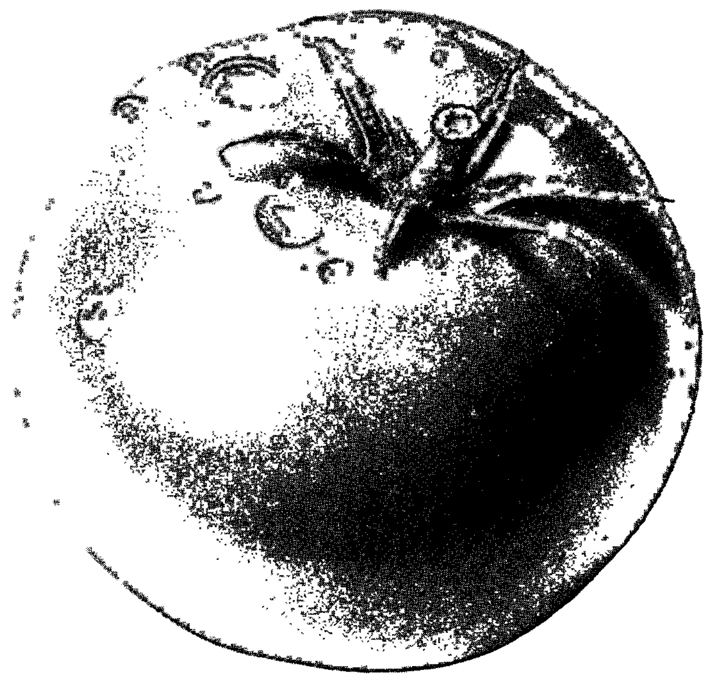


In Vermont, where I live, as in much of the rest of the United States, a gardener can select pretty much any sunny patch of ground, dig a small hole, put in a tomato seedling, and come back two months later and harvest something. Not necessarily a bumper crop of plump, unblemished fruits, but something. When I met Monica Ozores-Hampton, a vegetable specialist with the University of Florida, I asked her what would happen if I applied the same laissez-faire horticultural practices to a tomato plant in Florida. She shot me a sorrowful, slightly condescending look and replied, "Nothing."

"Nothing?" I asked.

"There would be nothing left of the seedling," she said. "Not a trace. The soil here doesn't have any nitrogen, so it wouldn't have grown at all. The ground holds no moisture, so unless you watered regularly, the plant would certainly die. And, if it somehow survived, insect pests, bacteria, and fungal diseases would destroy it." How can it be, then, that Florida is the source for one-third of the fresh tomatoes Americans eat? How did tomatoes become the Sunshine State's

TOMATOLAND



How Modern Industrial Agriculture Destroyed Our Most Alluring Fruit

BARRY ESTABROOK

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For the men and women who pick the food we eat

Notes

INTRODUCTION: ON THE TOMATO TRAIL

x **If you have ever eaten:** Statistics from the Florida Tomato Commission's *Tomato 101*, http://www.floridatomatoes.org/facts.html.

x **Americans bought $5 billion:** U.S. Department of Agriculture Economics, Statistics, and Market Information System, *U.S. Tomato Statistics,* Table 070 and 076. I multiplied the average retail price in 2009 by the total production.

x **In survey after survey:** See Christine M. Bruhn, Nancy Feldman, Carol Garlitz, Janice Harwood, Ernestine Ivans, Mary Marshall, Audrey Riley, Dorothy Thurber, Eunice Williamson, "Consumer Perceptions of Quality: Apricots, Cantaloupes, Peaches, Pears, Strawberries, and Tomatoes," *Journal of Food Quality* vol. 14, no. 3 (July 1991): pp. 187–95.

x **According to analyses:** Thomas F. Pawlick, author of *The End of Food: How the Food Industry Is Destroying Our Food Supply—And What You Can Do About It* (Fort Lee, NJ: Barricade Books, 2006), originally presented this information. I have updated it. The 1960s figures come from Bernice K. Watt and Annabel L. Merrill, *Composition of Foods: Raw, Processed, Prepared,* U.S. Department of Agriculture, Agricultural Research Service, Agricultural Handbook No. 8 (Washington, DC, 1964). My source for 2010 figures is the U.S. Department of Agriculture Nutrient Database for Standard Reference, Release 23: http://www.ars.usda.gov/SP2UserFiles/Place/12354500/Data/SR23/sr23_doc.pdf.

xi **A couple of winters ago:** Pawlick (see above) performed a similar "experiment."

xi **Little wonder that tomatoes are by far the most popular:** National Gardening Association, "The Impact of Home and Community Gardening in America" (2009), http://www.gardenresearch.com/index.php?q=show&id=3126.

xii **Regulations actually prohibit:** Federal Marketing Order No. 966 sets standards for tomatoes exported from most of Florida during the colder months.

xiii **To get a successful crop:** Stephen M. Olson and Bielinski Santos. eds., *Vegetable Production Handbook for Florida 2010–2011*, University of Florida (2010): pp. 295–316.

xii **Not all the chemicals stay behind:** The source is the Environmental Working Group, which compiled statistics from the U.S. Department of Agriculture's Pesticide Data Program and the U.S. Food and Drug Administration's Pesticide Monitoring Database.

xiv **The industry was nearly dealt:** For salmonella losses, see Mickie Anderson, "UF Research Finds Salmonella Responds Differently to Varieties, Ripeness," *University of Florida News*, September 21, 2010. For freeze losses see Laura Layden, "Florida Tomato Growers Eye Rebound from 2009–2010 Freeze-Ravaged Season," *Naples Daily News*, October 3, 2010. For the effects of glut, see Liam Pleven and Carolyn Cui, "Dying on the Vine: Tomato Prices—Tomatoes Go from Shortage to Glut in a Matter of Weeks," *Wall Street Journal,* June 17, 2010.

xiv **This has put a steady downward pressure:** Source for wage statistics is the Coalition of Immokalee Workers, http://www.ciw-online.org/Resources/10FactsFigures.pdf.

xv **The owners had crop insurance:** Michael Peltier, "The Other Side of the Freeze," *Naples Daily News*, February 8, 2010.

xv **And conditions are even worse:** See "From the Hands of a Slave" in this book.

xvi **Labor protections for workers predate the Great Depression:** Farmworkers were specifically exempted from the Fair Labor Standards Act of 1938, a key component of Franklin D. Roosevelt's New Deal.

ROOTS

1 **A Chilean Soldier was guarding:** A January 7, 2010, interview with Roger Chetelat in his office at the University of California Davis provided much of the information on the Atacama Desert expedition and tomato genetics. For a more scientific description, see Roger T. Chetelat, Ricardo A Pertuzé, Luis Faúndez, Elaine B. Graham, and Carl M. Jones, "Distribution, Ecology and Reproductive Biology of Wild Tomatoes and Related Nightshades from the Atacama Desert Region of Northern Chile," *Euphytica* vol. 166 (December 25, 2008): pp. 77–93.

2 **The Atacama Desert makes up:** See Yuling Bai and Pim Lindhout, "Domestication and Breeding of Tomatoes: What Have We Gained and What Can We Gain in the Future?," *Annals of Botany* vol. 100, issue 5 (August 23, 2007): pp. 1085–1094.

3 **one of our favorite vegetables:** Hayley Boriss and Henrich Brunke, "Commodity Profile: Tomatoes Fresh Market," University of California, Agricultural Marketing Resource Center (October 2005).

4 **When Hernán Cortés conquered:** For the history of the tomato, I drew on Andrew F. Smith, *The Tomato in America: Early History, Culture, and Cookery* (Columbia: University of South Carolina Press, 1994); and Arthur Allen, *Ripe: The Search for the Perfect Tomato* (Berkeley, CA: Counterpoint, 2010).

6 **Tomatoes' near-universal popularity:** A. W. Livingston, *Livingston and the Tomato,* forward and appendix by Andrew F. Smith (Columbus: Ohio State University Press, 1998). The autobiography of the great early plant breeder benefits enormously from Smith's writing and scholarship.

6 **"Well do I remember":** ibid p. 19

8 **Florida was a late comer:** For reference to Parry, Wilson, and Blund, see S. Bloem and R. F. Mizell, "Tomato IPM in Florida," University of Florida, Institute of Food and Agricultural Sciences Extension, Publication no. ENY706/IN178, http://edis.ifas.ufl.edu/in178. For Hendrix, see Benjamin Bahk and Mark Kehoe, "A Survey of Outflow Water Quality from Detention Ponds in Agriculture," Southwest Florida Water Management District (1977) and http://floridahistory.org/palmetto.htm.

9 **That was around the time**: See E. F. Kohman, "Ethylene Treatment of Tomatoes," *Industrial and Engineering Chemistry* (October 1931): pp. 1112–13.

9 **The Person most responsible:** Statistics from the U.S. Department of Agriculture Economics, Statistics, and Market Information System, Table 016, http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1210.

10 **Max Lipman:** See Carlene A. Thissen, *Immokalee's Fields of Hope* (New York: iUniverse, 2004); also the Web site of Six L's Packing Company, http://www.sixls.com.

12 **Born in Reading:** I am deeply in debt for information about Charles Rick from Arthur Allen, *Ripe: The Search for the Perfect Tomato* (Berkeley, CA: Counterpoint, 2010), which contains an excellent minibiography of the legendary plant science professor. I also drew on an interview and profile written by Craig Canine, "A Matter of Taste: Who Killed the Flavor in America's Supermarket Tomatoes?" *Eating Well* (January/February 1991): pp. 40–55.

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19 **When I met Monica Ozores-Hampton:** Details about commercial tomato horticulture in Florida in this chapter came from an interview with Ozores-Hampton on June 2, 2010. Any errors are my own. Information about the possible health effects about pesticides was taken from reports of the Pesticide Action Network and in no way reflects Ozores-Hampton's opinions.

24 **If those roots:** The Pesticide Action Network's database on methyl bromide can be accessed at http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC32864.

26 **more than one hundred chemicals:** See Stephen M. Olson and Bielinski Santos, eds., *Vegetable Production Handbook for Florida 2010–2011*, University of Florida Institute of Food and Agricultural Sciences (2010), pp. 295–316.

26 **Six of the recommended herbicides:** The Pesticide Action Network's database for agricultural chemicals can be found at http://www.pesticideinfo.org/Search_Chemicals.jsp#ChemSearch.

27 **A distressing number:** The Environmental Working Group compiled statistics from the U.S. Department of Agriculture's Pesticide Data Program and the U.S. Food and Drug Administration's Pesticide Monitoring Database. See also Thomas J. Stevens III and Richard L. Kilmer, "A Descriptive and Comparative Analysis of Pesticide Residues Found in Florida Tomatoes and Strawberries," University of Florida Institute of Food and Agricultural Sciences, 1999.

28 **Joseph Procacci agreed to take me:** The Procacci interview took place on March 2, 2005.

32 **To see the next phase:** Steven A. Sargent, Jeffrey K. Brecht, and Teresa Olczyk, "Handling Florida Vegetables Series: Round and Roma Tomato Types," University of Florida Institute of Food and Agricultural Sciences, 1989, gives a good overview of postharvest tomato packing.

32 **rise to 110 degrees:** Jeffrey K. Brecht, a postharvest physiologist at the University of Florida Research Center, made this statement at a workshop for packinghouse managers in 2006: http://www.gladescropcare.com/GCC_TPHMW.pdf.

32 **Despite such sanitation:** See *Program Information Manual: Retail Food Protection Storage and Handling of Tomatoes*, U.S. Food and Drug Administration (June 10, 2010), http://www.fda.gov/food/foodsafety/retailfoodprotection/industryandregulatoryassistanceandtrainingresources/ucm113843.htm; and Martha Roberts, Florida Tomato Committee, (in an address to the 2006 Florida Tomato Institute, http://www.gladescropcare.com/GCC_TPHMW.pdf).

CHEMICAL WARFARE

35 **Tower Cabins is a labor camp:** "Why Was Carlitos Born This Way?"—the story of the birth defects in Immokalee—was broken on March 13, 2005, in the *Palm Beach Post* by reporter John Lantigua. I am in debt to Lantigua and his colleagues Christine Stapleton and Christine Evans for many of the details of this tragedy, which might never have come to light had it not been for their doggedness and insightfulness.

35 **But in the lives of tomato workers:** Geoffrey M. Calvert, Walter A. Alarcon, Ann Chelminski, Mark S. Crowley, Rosanna Barrett, Adolfo Correa, Sheila Higgins, Hugo L. Leon, Jane Correia, Alan Becker, Ruth M. Allen, and Elizabeth Evans, "Case Report: Three Farmworkers Give Birth to Infants with Birth Defects Closely Grouped in Time and Place—Florida and North Carolina, 2004–2005," *Environmental Health Perspectives* vol. 115, no. 5 (May 2007): pp. 787–91.

36 **Many of them were rated "highly toxic":** The Pesticide Action Network's database for agricultural chemicals is http://www.pesticideinfo.org/Search_Chemicals.jsp#ChemSearch.

36 **"restricted entry intervals":** For a list of pesticides used on tomatoes in Florida and their restricted entry intervals, see "Florida Crop/Pest Management Profiles: Tomatoes," University of Florida, Institute of Food and Agricultural Sciences (March 2009). http://edis.ifas.ufl.edu/pi039.

37 **Although regulations require:** These regulations vary depending on which pesticide is used. For the U.S. Environmental Protection Agency's Worker Protection Standard for Agricultural Pesticides, see http://www.epa.gov/oecaagct/twor.html.

38 **As soon as I met him:** Much of the background material in this chapter came from a June 2, 2010, interview with Andrew Yaffa.

41 **In terms of raw quantities:** "Agricultural Chemical Usage 2006 Vegetable Summary," U.S. Department of Agriculture, National Agricultural Statistics Service (July 2007).

41 **Employing only about fifty inspectors:** "Abundance of Poisons, Shortage of Monitoring," *Palm Beach Post*, May, 1, 2005.

41 **workforce of roughly 400,000:** "National Agricultural Workers Survey," U.S. Department of Labor Employment and Training Administration, October 5, 2010 (Washington, D.C.).

42 **Together for Agricultural Safety:** See Joan Flocks, Leslie Clarke, Stan Albrecht, Carol Bryant, Paul Monaghan, and Holly Baker, "Implementing a Community-Based Social Marketing Project to Improve Agricultural Worker Health," *Environmental Health Perspectives Supplements* vol. 109, no. S3 (June 2001): pp. 461–688.

42 **less than 8 percent:** John Lantigua, "Why Was Carlitos Born This Way?" *Palm Beach Post*, March 13, 2005.

42 **leveled eighty-eight counts:** Laura Layden, "Judge: Drop Most Violations against Ag-Mart," *Naples Daily News*, March 23, 2007.

43 **A scathing portrait:** Shelly Davis and Rebecca Schleifer, "Indifference to Safety: Florida's Investigation into Pesticide Poisoning of Farmworkers," Farmworker Justice (1998), Washington, DC, http://www.farmworkerjustice.org/pesticides/173-indifference-to-safety.

43 **agricultural workers are more likely to be poisoned:** See *Worker Health Chartbook, 2004*, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institution for Occupational Safety