SIX

IRON HORSES

Nature and the Building of the First U.S. Transcontinental Railroad

On a may morning in 1869, 690 miles east of Sacramento and 1,086 miles west of Omaha, a small crowd gathered to witness the driving of the final spike in an ambitious project: a single railroad line that spanned the remote western interior of North America. For six years, laborers for the Central Pacific had laid tracks eastward over the Sierra Nevada and across the Great Basin desert. At last they had pushed the construction into the Promontory Mountains, a dry, windswept range that jutted south into the Great Salt Lake. There, in a high, sun-drenched valley encircled by ridges still covered with patches of snow, they met the crews of the Union Pacific, which since 1864 had been toiling west across the Great Plains, through the Rockies and the Wasatch Range, and up the last grade to Promontory Summit. Now, in the cool, clear air, some five thousand feet above sea level, amid the sagebrush, bunchgrass, and juniper, several hundred people came together at the spot where the rails would converge.[1]

The members of the group hailed not just from the United States but also from countries as distant as Ireland and China. There were Central Pacific Railroad and Union Pacific Railroad Company officials, state and territorial governors, Mormon dignitaries from Ogden and Salt Lake City, journalists and photographers, a smattering of women and children, and a band. To one side, the troops and musicians of the 21st U.S. Infantry stood at parade rest. Mostly there were the railroad laborers, lean, weathered, and roughly clothed. "Grouped in picturesque confusion," wrote one observer, "were men of every color, creed, and nationality—the Indian, the Mongolian, the Saxon,

the Celt, and the half-caste Mexican, some arrayed in gorgeous costumes, and some innocent of any, mingling freely with American citizens and soldiers." Although the description no doubt exaggerated the scene, it surely revealed a general awareness that the people in attendance—in particular, the laborers whose brains and brawn had built the railroad—were not of one racial type or ethnic identity. The world had come to America, and America had become, in effect, the world.[2]

If the Promontory Mountains and the valley landscape provided the backdrop for the diverse gathering, things of another nature—the railroad and its components—formed the immediate frame. Locomotives loomed on either side. The Central Pacific's *Jupiter*, a wood-burning engine with a distinctive funnel-shaped bonnet smokestack designed to arrest sparks and prevent fires, pointed due east. The Union Pacific's *No. 119*, a coal-burner with a tall, straight stack, faced due west. Each machine sat atop its own distinctive tracks. The Central Pacific's wood crossties were standardized and clean-cut with squared edges, while the Union Pacific's were rough-hewn and irregular. Telegraph lines ran parallel to the rails; atop one pole an American flag snapped in the breeze. Horses, some hitched to wagons and others carrying riders, stood on the edges of the crowd, highlighting the transition from animal to machine power that the railroad represented.[3]

The organizers of the ceremony intended it to celebrate the transcendent purpose they perceived in the land. Just before noon, to the cheers of the crowd and the shrieks of locomotive whistles, a Chinese crew from the Central Pacific and an Irish gang representing the Union Pacific each brought forward a final rail. The Rev. Dr. John Todd offered a prayer, thanking God for his blessings and asking that he acknowledge the railroad as "a monument of our faith and our good works." With his help, Todd intoned, "this mighty enterprise may be unto us as the Atlantic of thy strength, and the Pacific of thy love, through Jesus, the Redeemer."[4]

Leland Stanford, the Central Pacific president and former California governor, then received an array of ceremonial spikes to be fitted into pre-drilled holes in a polished laurel tie. Arizona presented a spike plated with silver and gold; Nevada's was made of silver. The California spike, destined to become the most famous of all, contained eighteen ounces of pure gold. "The Last Spike" was engraved on its head, and on its side appeared these words: "May God continue the unity of our Country as this railroad unites the two great Oceans of the world." Stanford accepted the spikes and spoke of the railroad's

great commercial promise. Grenville Dodge of the Union Pacific addressed the crowd, invoking the memory of Sen. Thomas Hart Benton of Missouri, an enthusiastic proponent of the transcontinental railroad: "The great Benton prophesied that some day a granite statue of Columbus would be erected on the highest peak of the Rocky Mountains, pointing westward, denoting the great route across the continent. You have made the prophecy today a fact. This is the way to India."[5]

Then the ceremony reached its high point, a symbolic culmination of the labor that had transformed earthen materials into an instrument of extraordinary mechanical power. Samuel Reed of the Union Pacific and James Strobridge of the Central Pacific positioned the laurel tie. The Chinese and Irish tracklayers put the last two rails in place, and various officials and dignitaries drove the penultimate spikes. Standing over the final iron spike, Stanford and Thomas Durant, the Union Pacific's vice president, looked at each other. They raised their hammers, and in turn—first Stanford, then Durant—brought them down. That the moguls and their soft, untrained muscles missed the spike detracted nothing from the significance of their swings.[6]

The news—"DONE"—shot down the telegraph lines. In cities around the nation, cannons boomed, gongs sounded, steam whistles screamed, alarms pealed, bands played, fireworks exploded, and thousands upon thousands of people cheered. In San Francisco, artillery thundered over the ocean. Locomotive crews in Omaha yanked their whistles while a crowd exulted. At Independence Hall in Philadelphia, where more than ninety years earlier the Continental Congress had promulgated the Declaration of Independence, the bells rang with the sound of an expanding nation.[7]

Back at Promontory Summit, Union Pacific photographer Andrew Russell recorded an image that would become an icon of the American experience. The *Jupiter* and the *No. 119* moved so close that their cowcatchers almost touched. The crowd parted, giving Russell a clear shot. Workmen leaned forward from the locomotive pilots, extending champagne bottles. Below them, chief engineers Samuel Montague and Grenville Dodge clasped hands. To people then and since, Russell's picture symbolized the marriage of the rails, the joining of East and West, and the fulfillment of national destiny, human purpose, and natural potential.[8]

Like every icon of American history, the surface features of the last spike and the joining of the rails provide clues to a deeper ecological story. Embodied in every feature of the scene in Russell's photograph were the close

connections between an expanding nation and the biophysical conditions that have shaped and reshaped life on Earth. Basic to those connections was the land itself. Laying the tracks across hundreds of miles of space involved a fundamental encounter with rock, soil, water, and topography. The railroads passed over deserts and prairies, moved through canyons and across rivers, and climbed mountains. In part, the Earth determined the route and the pace of construction, as high elevations blocked, gaps and canyons invited, and gentle gradients offered paths of least resistance. In part, the Central Pacific and Union Pacific Railroad companies decided the way, by excavating cuts, filling ravines, erecting bridges, drilling wells, and boring tunnels. If the geometric ideal of the straight line was the railroads' goal, they still had to consider the steepness of the grade, the widths of the canyons, the hardness of the rocks, the relative merits of potential mountain passes, and—crucially important for steam power—the locations of streams, springs, and underground bodies of water. When the locomotives finally met in Utah, behind them stretched a tremendous story of the way earthen resources and human manipulations made possible a continuous mechanized path across the American West.

The railroads' vital connection to nature included their material composition and thermodynamic function. To lay tracks and run trains, the two lines incorporated enormous quantities of resources, some of them from extreme distances. Laborers extracted iron from the Earth, purified it in blast furnaces, and, in foundries, mills, and machine shops, turned it into rails, spikes, and locomotives such as the *Jupiter* and the *No. 119*. In each engine, the iron components redirected two fundamental physical processes—steam pressure and atmospheric pressure—to create mechanical power. Boiling water produced steam that rushed into horizontal cylinders located at the front of the engine. As the steam entered each cylinder, it pushed a piston forward. As the steam escaped through a vent, it left a vacuum in the cylinder, and the pressure of the Earth's atmosphere shoved the piston back into the void. Each stroke—first from steam, then from atmospheric pressure—made a distinctive chuffing sound, as the reciprocating piston alternately pushed and pulled a drive rod that turned the large locomotive drive wheels and propelled the train along the track.[9]

The railroad's connection to nature went deeper still. As metallic and mechanical as it was, the movement of a locomotive required the miracle of organic life. The timbers and boards that composed bridges and poles, the

crossties that held rails, and the chunks of wood in the *Jupiter's* firebox—how many trees, how many forests, succumbed to the ax? Looking at Russell's picture, it is easy to miss a remarkable paradox: that a technology epitomized by iron and steel relied so heavily on plants. Not all those plants were cut live. Excavated from underground deposits, ton upon ton of coal burned in furnaces, foundries, and the fireboxes of locomotives such as *No. 119*. And whether of coal or cordwood, combustion—a chemical reaction essential to life on Earth—powered the engines to Promontory.[10]

Of all the material paradoxes at the heart of the last-spike ceremony, the greatest was nearly absent from Russell's iconic portrait. Creating the mechanical power of the locomotives—the burning of fuel and the boiling of water that drove the movement of metal on metal—necessitated incalculable expenditures of muscular energy. Moving earth, rails, ties, wood, and other materials required draft animals, especially horses. Although those animals stood on the periphery of the last-spike ceremony, it could not have taken place without their grass-eating, water-slurping, metabolizing, sweating, farting, defecating bodies. Nor, for that matter, could the locomotives have chuffed their way up the grades to Promontory without the muscle power of humans. In the days before steam shovels and bulldozers, it took men and horses to move mountains. Much as the railroad drew iron or wood from far away, so, too, did it draw muscles from distant environments: pastures in California, villages in China, farms in Ireland. More than anything else, muscle power—animal power—showed that the railroad, which could seem so artificial, so antithetical to living, breathing nature, was at its heart a profoundly organic creature. For good reason was a steam engine called an "iron horse" and its capacity to move and pull calculated in units of horse power.[11]

When officials and dignitaries made their pronouncements—when they spoke of the railroad as uniting the two great oceans of the world, as opening the fabled passage to India, or as the divinely inspired realization of national destiny—they attached high purpose to a moment in history when nations like the United States built industrial systems out of the natural substances of the planet. Fully understanding that great transformation and what it meant to the people who lived it requires more than an analysis of the last spike or a perusal of Russell's famous image. It requires an excursion down the rails into the earthy history of the nineteenth-century American republic.

WESTWARD THE STAR OF EMPIRE TAKES ITS WAY

Long before the meeting of the rails in that high mountain valley, Americans dreamed of a transcontinental railroad that would bring them wealth and power and fulfill the promise of what Thomas Jefferson called the "empire of liberty." Through the mid-nineteenth century, visionaries put forth ideas for a line of tracks that would stimulate commerce, carry civilization to savage and heathen peoples, unite America's disparate parts, and extend the nation's control across prairies, mountains, and deserts to the Pacific. "Are we chimerical in this opinion?" asked the *New Orleans Bee* in 1836. "If we live for 10 years more, we may then exclaim with the poet—Westward the star of empire takes its way." The journalist William Gaylord Clark added in 1838: "Let the prediction be marked. This great chain of communication will yet be made, with links of iron. . . . The granite mountain will melt before the hand of enterprise; valleys will be raised, and the unwearying fire-steed will spout his hot, white breath where silence has reigned since the morning hymn of young creation was pealed over mountain, flood, and field." Clark issued his forecast at a time when the United States did not yet have three thousand miles of track, but already the locomotive—"the unwearying fire-steed"—had begun to capture the imagination of people who believed that the nation's future would unfold in the far West.[12]

Events in the 1840s inspired a flurry of calls for a Pacific railroad. In 1846, the United States acquired the Oregon country through diplomatic negotiations with Britain. In 1848, following war, the nation took control of the northern provinces of Mexico. That same year, thousands of freebooters began rushing into California in search of gold. With the far West open for business, a chorus of voices sang the praises of a railroad that would enable the full exploitation of the region's natural resources and that would boost America to global prominence. New York businessman Asa Whitney declared that the line "would open the wilderness to the husbandman, and take the products of the soil to all the markets of the world." The railroad would "be the avenue of all the trade between Western Europe and all China and India," the *Philadelphia Public Ledger* predicted. And promoter William Gilpin asserted that it would be "a great artificial monument, an iron path, a NATIONAL railway to the *Western* Sea."[13]

No railroad proponent exceeded Senator Thomas Hart Benton of Missouri in sheer grandiosity of vision. Exemplifying a point of view that the

art historian Albert Boime called the "magisterial gaze," Benton pictured an enormous stone monument at the continental crest, facing the setting sun and proclaiming the American triumph: "And let [the railroad] be adorned with its crowning honor, the colossal statue of the great Columbus . . . hewn from the granite mass of a peak of the Rocky Mountains overlooking the road, the mountain itself the pedestal, and the statue a part of the mountain, pointing with outstretched arm to the western horizon, and saying to the flying passenger, 'There is the East! There is India!'"[14]

In order for such fantasies to materialize, the United States first had to settle important questions. Would the federal government sponsor the project, or would private interests take responsibility for it? More important, what route would the railroad take? Would it follow a northern path across the continent or a central or a southern one? Where would the line begin? Chicago? St. Louis? New Orleans? Into the 1850s, cities, states, and their representatives in Congress competed with one another to claim the eastern terminus. Tensions increased when the railroad's location became a political issue between northern and southern states. Each section, North and South, sought a route that would favor it economically and help it dominate the West.[15]

Some Americans believed nature could break the deadlock. Finding the most optimal route—the easiest and least expensive to build, the most efficient on which to run trains, the one, in short, along which nature posed the fewest obstacles—would decide the issue. As the historian William Goetzmann concluded, resorting to the "disinterested judgement of science . . . was a way of letting nature . . . decide, not only because it placed the decision beyond the control of mere mortals but also because the decision seemed to depend on the overarching justice of the natural law."[16]

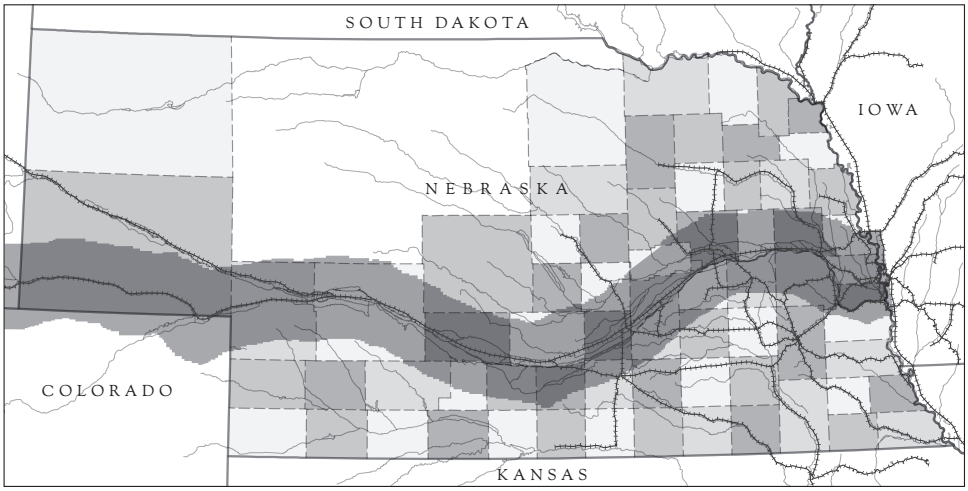
In 1853, Congress authorized a comprehensive final search for the one best route to carry the star of empire westward. The U.S. Army's Corps of Topographical Engineers, an agency dedicated to the scientific study of nature, surveyed three potential transcontinental locations, north, central, and south. Traversing prairies, mountains, rivers, and deserts, the army explorers gathered detailed information about the land and its resources. But when the officers finally reported their findings, they did not speak in one voice. Each way had advantages and disadvantages, and the information about each was so varied and complex as to defy easy comparison. Rather than resolve the issue of the one best route, the railroad surveys further confused it, adding to the political paralysis that hindered the progress of empire.[17]

The outbreak of the Civil War in 1861 at last removed the impasse. With southerners absent from Congress, the remaining senators and representatives turned their attention to the railroad. All the nationalist and imperial reasons for the line still held, but the war added one more crucially important motivation: the project was imperative if the Union wanted to avoid further fragmentation. A railroad would connect the West to the rest of the nation, "linking by a great federative bond," Senator Milton Latham of California said, "the whole political fabric from ocean to ocean."[18]

Accordingly, Congress passed and Abraham Lincoln signed into law the Pacific Railway Act of 1862.[19] The measure authorized an existing California corporation, the Central Pacific Railroad, to build east across the Sierra Nevada. It chartered a new business, the Union Pacific Railroad, to forge west from Nebraska. The act allowed each line to lay its tracks across public land, and it permitted each to gather earth, stone, and timber from that land for construction materials. For every mile of track put down, the federal government would reward each railroad with money. A mile of track over relatively level terrain would earn the Central Pacific or Union Pacific a loan of government bonds worth $16,000. In the Sierra Nevada and Rockies, where the challenges of steep terrain, rock, and bad weather would require more laborers, draft animals, food, fuel, and explosives, along with larger engines and heavier rails, each mile would accrue bonds valued at $48,000. Across the Great Basin, which posed additional environmental obstacles, the amount would be $32,000 for every mile. A revision of the act in 1864 also enabled the railroads to sell bonds to private investors, which was necessary because the federal government's support was insufficient to pay for the initial construction.[20]

Just as important as payment in money, the Pacific Railway Act and the 1864 revision stipulated that each mile of track constructed would earn from the government a form of natural capital: land. For every mile of bed, ties, and rails, the Central Pacific or Union Pacific could claim ten alternating square miles, five on either side of the line. The 1864 law increased this amount to twenty alternating square miles, ten on each side of the line, for a total of 12,800 acres of land for every mile of track. The railroads could, if they chose, harvest timber and, by the later amendment, mine coal from these enormous terrestrial checkerboards. Or the corporations could sell the land for cash.

By such means were the Central Pacific and Union Pacific to proceed toward their final meeting. Now the star of empire could make its way over the grasses, arid spaces, forests, and mountain ridges of the West.



Union Pacific Railroad, the accompanying federal land grant, and branch lines and counties in Nebraska, 1880. The tracks generally follow watercourses and other natural contours, while the county boundaries reflect the rectangular pattern of the federal survey grid.

THE LORD HAD SO CONSTRUCTED THE COUNTRY

The extension of the railroads across that vastness began with teams of engineers who tried to pinpoint the location of the lines. These men were students of nature, of geology, materials, and fundamental physical forces. Trained in the sciences of land survey and structural design, they mapped and diagrammed the curves, grades, cuts, fills, tunnels, and bridges that would carry the tracks. Some imagined a higher purpose in their work. It was a heroic struggle to overcome a wild land; a masculine encounter with elemental nature; an intelligent use of valleys, ridges, passes, and other natural formations that manifested God's design. "The Lord had so constructed the country," wrote Grenville Dodge, "that any engineer who failed to take advantage of the great open road . . . would not have been fit to belong to the profession." Mostly, though, it was tedious, physically taxing, bewildering work in lonely and fearsome landscapes where finding the way was more a matter of luck or politics than of providence—and where the route chosen might leave much to be desired.[21]

Theodore Judah found an avenue through the Sierra Nevada. A New Yorker, he had earned a reputation as a skilled, resourceful, energetic engineer while working on several eastern railroad construction projects. In 1854, he

went to California to survey some of the state's first railways. Driven by professional ambition and dreams of glory, he became such a passionate advocate of a transcontinental line that acquaintances referred to him as "Crazy Judah." In 1856, with the support of California boosters, he traveled to Washington, D.C., to lobby Congress for federal sponsorship of the project. Frustrated by the sectional split that stymied legislation, he determined to begin the work himself. Returning to California in 1860, he searched for a route across the Sierra Nevada. While exploring the western foothills, he met "Doc" Strong, a druggist in the town of Dutch Flat. Strong guided Judah many miles up a long, steadily rising ridge flanked by rivers—the American on the south, the Bear on the north. The ridge ended at Donner Pass, and from there Judah looked down on crystalline Donner Lake, its outlet into the Truckee River canyon, and the route into Nevada, which would pass relatively close to the Comstock mining district. Perhaps he wasn't so crazy after all. Back at Dutch Flat, he and Strong drafted the articles of incorporation for a railroad. By 1861 they had lined up investors, and the Central Pacific became a reality.[22]

Early that year, Judah began a series of intensive surveys that brought him into intimate contact with the nature of the Sierra Nevada and yielded the final plans for the Central Pacific's transmountain path. Beginning at Sacramento, aided by a team of ten to fifteen assistants, he examined environmental conditions and fixed the railroad's route. To decide the general direction, he noted "water-courses, ravines, the elevations to be overcome, the undulations of the ground, the most feasible points for crossing rivers, and the character of the soil." Then, with a measuring chain and a transit for recording angles, he and his survey party established and mapped the precise line that the tracks would follow, including distances and curves. Next, using a barometer and a level, Judah and his men noted elevations along the line. Plotted on a chart was the route's profile, a "vertical representation of the surface of the ground and its undulations." Finally, on the basis of the line and the profile, Judah calculated the railroad's grade, its degree of inclination, or slope, of which the lowest possible was the objective. For the sake of efficiency, "excavations and embankments," the cuts and fills of the grade, would "balance each other as nearly as possible." Physical conditions compounded the intellectual challenge of surveying. Judah and his team had to contend with inclement weather, balky horses, and steep, dangerous terrain. Evidently this was not, as in Grenville Dodge's conceptualization, the great open road of God; rather, as Judah said at one point, it was "the most difficult country ever conceived of for a Rail Road."[23]

The work had its rewards. At times the party enjoyed the beauty of the mountains. When Judah's wife, Anna, joined him, she brought a sketchpad, and her drawings later illustrated the Central Pacific's original stock certificates. More important, Judah learned essential facts about the mountain environment. He noted the many kinds of trees—pine, fir, cedar, and tamarack—that would be useful in building the railroad. He recorded the hardness of the Sierra Nevada granite, anticipating "quite heavy rock-cutting" during construction. And he collected evidence of snow. Hard winters made some people doubt that a railroad across the mountains was possible. Indeed, the pass took its name from the Donner party, overland migrants who, trapped while attempting a crossing in 1846, resorted to cannibalism to survive. But no official record of the snow's average accumulation existed. To find out, Judah looked closely at the trees. Thirteen feet seemed to be an important marker: he saw broken branches and ax marks above that height, and below it, a lack of moss. Thirteen feet—extraordinarily heavy snow—but surely it didn't come down all at once. With the application of Yankee ingenuity, Judah thought, the railroad would make it through.[24]

In 1862, Judah completed the final maps and plans for a railroad over the Sierra Nevada. Beginning at the foot of K Street in Sacramento, the line would run about one hundred miles to the summit, for a total elevation gain of some seven thousand feet. Rising a maximum of 105 feet per mile, it would follow the long ridge between the American and Bear rivers, moving "from gap to gap"—from low point to low point—along the rocky spine. Judah foresaw no major river or canyon crossings, so the line would have no unusually high or long trestles. It would, however, have many cuts and fills and would require eighteen tunnels through the dense granite. From Donner Pass the railroad would drop down into Nevada, finally meeting the oncoming tracks of the Union Pacific somewhere in the hazy distance.[25]

Although Judah prepared his plans carefully, they contained one especially controversial feature—his determination of the western base of the Sierra Nevada. Identifying that point was crucial, because there the Central Pacific would begin to receive government bonds valued at $48,000 per mile, well above the $16,000 rate for relatively flat land. Judah believed the base was near Newcastle, some thirty miles east of Sacramento. Leland Stanford, Charles Crocker, and other members of the board of directors were hungry for capital, and they decided that his calculation was not advantageous enough to the railroad. Stanford asked the California state geologist, Josiah Whitney, for an

opinion. Whitney's decision reflected corporate needs and ambitions more than objective geological conditions. About seven miles east of Sacramento, where the survey line crossed Arcade Creek near its confluence with the American River, the professor detected a slight rise in the terrain which, he thought, might reasonably be called the beginning of the mountains. Whitney's selection of the site was fraudulent, Judah charged, but Stanford and the other directors paid no heed to the engineer, whose financial power and influence they were already taking steps to minimize. They transmitted Whitney's report to President Abraham Lincoln, who named Arcade Creek the beginning of the corporation's mountain miles. Thus the politics of nature, not simply nature, shaped the Central Pacific's progress.[26]

Judah would not live to see the tracks pass Arcade Creek. In 1863, crossing Panama on his way to New York to raise capital that would help him regain control of the Central Pacific, he contracted yellow fever from a mosquito. By then, the corporation no longer needed him. Using his plans and guided by the expertise of a new chief engineer, Samuel Montague, the corporation was poised to transform what had been fantasy into hard, material reality.[27]

Meanwhile, hundreds of miles to the east, the Union Pacific Railroad Company prepared to send its own engineers and survey crews across the Great Plains and into the Rockies. Chartered by the Pacific Railway Act, the Union Pacific came into existence in 1862 and 1863 when investors purchased stock in the corporation and appointed its first officers. These businessmen, including vice president Thomas Durant, hired Peter Dey as chief engineer and ordered him to complete a survey. Dey had a longer distance to cover than did Judah, his Central Pacific counterpart, and he had to consider a wider range of potential routes. He couldn't do the work himself, as Judah had done; he needed teams of men to complete the job.[28]

In 1864–1865, Dey sent no fewer than four parties across the prairies, through the Rocky Mountains, and into the Great Basin in search of a way that would combine minimum grades, curves, and crossings with the shortest possible distance. One team followed the geographically easy Platte River route, well trod by overland migrants in covered wagons. Another roamed Colorado's formidable Front Range, probing for a potential route through the mountain wall. A third headed into the mountains, deserts, and prairies that later would be incorporated into Wyoming. The fourth group went straight to the Wasatch Range in Utah, the last of the Rocky Mountains before the Great Basin and the eventual meeting with the Central Pacific. Moving across the landscape, the

surveyors slowly established a line, profile, and grade, and they noted useful timber and mineral resources, especially timber and coal.[29]

It was arduous work, for nature presented many challenges: the Black Hills (now the Laramie Mountains) of southeastern Wyoming, a seemingly impenetrable barrier of steep slopes, rock outcrops, and deep gulches; farther west the Red Desert, an enclosed basin some two hundred miles wide with almost no fresh water; and finally Echo and Weber canyons, rugged slashes in Utah's Wasatch Range. Harsh conditions punished the bodies of the surveyors and their horses. Crossing the Red Desert, their tongues swelled from lack of water; drinking from a brackish alkali lake, they fell desperately ill. To the west, in the sagebrush and greasewood country beyond the Green River, one party member thought the tepid water tasted like lye.[30]

Despite such hardships, some of the men reveled in a strenuous masculine experience that brought them close to wild nature. Among others, Samuel B. Reed—in charge of the Wasatch survey and later the Union Pacific construction—enjoyed the striking geological formations, the meals of trout and venison, the crystalline air, the challenge of advancing a line through the wilderness. "The scenery is magnificent," he exulted, writing of Weber Canyon, with "mountains composed of granite and gneiss towering four to five thousand feet above us. The deep narrow gorge in which the river runs is only about 300 feet wide and is the wildest place you can imagine." As Union Pacific historian Maury Klein has observed, Reed and the other engineers experienced "the pilgrimage from civilization back to nature," a central theme in nineteenth-century European American history. Reed and his compatriots, of course, missed the irony of their journey: a return to wildness for the purpose of building a technology that would help to sweep that wildness aside.[31]

By 1867, the surveyors, now under the supervision of a new chief engineer, Grenville Dodge, had completed the basic work. There would be additional tasks—marking the cuts and fills for the road builders, staking the location of ties and rails for the tracklayers, designing tunnels and trestles—but otherwise the draftsmen were hard at work inking the maps. From Omaha, the railroad would follow the Platte River over the seemingly interminable Nebraska prairie. In the far southwestern corner of the state, after briefly crossing into Colorado to the town of Julesburg, the line would curve along Lodgepole Creek into Wyoming. Then came "the natural pass over the Rocky mountains," as Dodge called it. Traversing a ridge between Crow and Lone Tree creeks, as significant—and as problematic—a choice as the route that Doc Strong had revealed

to Theodore Judah, the tracks would head into the rugged Black Hills and across Sherman Summit, at 8,236 feet the highest point on the entire transcontinental route, higher even than Donner Pass in the Sierra Nevada. After a sudden elevation drop, the railroad would make its way over the expanse of southern Wyoming. It would travel along creeks and rivers, skirt mountains, and slice through the Red Desert. Leaving Bitter Creek, it would cross the Green River. A series of streams—Blacks Fork, Muddy Creek, and Bear River—would guide the line into Utah, where it would angle west through Echo and Weber canyons on its way toward its ultimate link with the eastward-moving Central Pacific tracks.[32]

The Lord had so constructed the country, Dodge said, and the engineers certainly had done their best to take advantage of the route that the Almighty—or nature's contingency—had laid down for them. But now their task changed. Now it was time to supervise the construction of roadbed, tunnels, bridges, and track. The brainwork already was under way. Now muscles would move; now earth would shift.

INSATIABLE APPETITE

In February 1863, from K Street in Sacramento, the Central Pacific's contractors began shoveling and scraping rock and soil into a linear bed that soon left the city and headed northeast into the countryside. Passing irrigated fields and orchards, moving through rangeland grazed by cattle and horses, the graders built the bed across the gentle terrain, which rose only 129 feet over 18 miles to a town called Roseville. Tracklayers followed the graders, placing ties and spiking down rails. Beyond Roseville, the workmen gradually pushed into the high country, up through oak and manzanita in the foothills and then, farther on, into pines, tamarack, and fir, fragrant in the warm air. Up the railroad went, through cuts, across fills and bridges, and toward the summit. In November, the Central Pacific fired up its first locomotive. By December, the engine could roll a mile beyond the American River bridge on the outskirts of Sacramento. In the summer of 1864, the tracks reached the town of Newcastle, 31 miles out. By June 1865, trains ran 43 miles to Clipper Gap, and by October, the tracks made it to Colfax, a mountain settlement 54 miles from the point of beginning.[33]

The Union Pacific started more slowly, but like a locomotive building a head of steam, it gathered momentum as it moved along the line. In March 1864, while the Central Pacific crews were preparing to advance into the Sierra

Nevada, a small Union Pacific workforce on a muddy street in Omaha began throwing up earth into a roadbed. Not until July 1865 did the first rails go down, and by the end of that year only forty miles of track could carry a Union Pacific train. But in 1866 the prairie miles began rapidly to fall away. By June, tracklayers had completed one hundred miles of road. In October, 247 miles out, they crossed the hundredth meridian, the rough dividing line between the tallgrass prairie of the humid East and the dry prairie of the West, with its wiry shortgrasses, spiky yuccas, and dusty sagebrush. By late December they had reached 305 miles, far up the Platte Valley.[34]

In these opening phases of construction, the transcontinental railroad manifested some of its deepest connections to nature. Building bed, laying track, and running trains not only required the railroad to follow what seemed to be the most natural route across the West; the project also required industrialists to extract, modify, and use vast quantities of natural substances. From its earthen bed to its iron locomotives and its ties and fuel wood, the railroad was a powerful system—a massive force—that sucked up raw materials, some of them from environments far away.[35]

In effect, the construction of the Central Pacific and Union Pacific railroads began not at Sacramento and Omaha but at the places where workmen procured the materials necessary for manufacturing spikes, rails, car wheels, and locomotives. In New Jersey, New York, and Pennsylvania, iron miners pierced the bedrock with drills, blasting powder, picks, and shovels. First digging pits, then excavating underground, they removed the ore and transported it by wagon to mills where other workers crushed and washed it, separating as much of the iron as possible from the rock that contained it. Then, by wagon, canal boat, and railroad, the ore went to Pennsylvania bloomeries and blast furnaces. There laborers heated it with fuels drawn from subsidiary environments. Charcoal made from trees fired the bloomeries; coal and its refined form, coke, burned in the furnaces. Ore, fuel, and heat, whether in bloomeries or furnaces, yielded a bright orange stream of purified iron.[36]

After it cooled, the iron went to factories that turned it into railroad components. At Johnstown, Danville, Allentown, Scranton, and other Pennsylvania industrial centers, mills rolled the iron into rails. The Cambria Rolling Mills at Johnstown and the Lackawanna Iron Company at Scranton, among other operations, manufactured rails for both the Central Pacific and the Union Pacific. Some iron went to foundries and forges, where workmen and machines squeezed, cast, and hammered it into car and locomotive parts. Danforth,

Cooke, and Company of Paterson, New Jersey, Norris and Company of Philadelphia, and William Mason and Company of Taunton, Massachusetts, fabricated the first locomotives for the Pacific railroad. The Schenectady Locomotive Works in New York state built the Central Pacific Railroad's *Jupiter*. The Rogers Locomotive Works of Paterson, New Jersey, constructed the Union Pacific Railroad's *No. 119*.[37]

Finally, rails, locomotives, and other iron materials made their way to the American West and to the construction sites of the Central Pacific and Union Pacific. Some went by wood-fired steamboat to Omaha; some shipped out from Philadelphia and other eastern seaports and traveled by sail around Cape Horn or by sail to Panama and across the isthmus by railroad before reaching Sacramento.[38]

The railroads' intense demand for iron was matched by their enormous consumption of wood. The farther they built into the West, the greater their need for fuel, crossties, and bridges and other structures. The two corporations extracted some of the material from the environments through which they built their lines and some of it from distant places. The hunger for trees that typified the Central Pacific, the Union Pacific, and other lines moved one commentator to call the nineteenth-century American railroad "the insatiable juggernaut of the vegetable world."[39]

The Central Pacific easily exploited the forest wealth of California and the far West. Schooners arrived at the Sacramento wharf laden with timber from the state's coast range and from Puget Sound and other points in the Pacific Northwest. By October 1865, the corporation had laid some 135,000 redwood ties, around 2,500 per mile of track. When the line pushed into the mountains, the railroad no longer had to import wood. Workmen cut a swath roughly sixty to two hundred feet wide through the trees, yielding an abundance of pine, tamarack, cedar, and fir, much of which became ties or went into locomotive fireboxes. Much of the rest fueled a lumber boom. By 1867, twenty-four sawmills on the Truckee River spewed some twenty-five thousand board feet of lumber per day, providing the Central Pacific with material for bridges and other structures.[40]

As it built toward the Rocky Mountains, the Union Pacific similarly took in wood from near and far. Axmen and sawyers harvested cedar, oak, and cottonwood from along the Missouri River, one hundred miles upstream and sixty miles downstream from Omaha. Meanwhile, woodchoppers labored far up the Platte River, cutting cedar from nearby draws and stripping cottonwood

from groves next to the stream. Along both the Missouri and the Platte, wood came from land that the Union Pacific had purchased or acquired in its grant, from unclaimed public domain, and from private land under contract. In a few instances, cutters invaded the homesteads of squatters. Because these settlers did not yet have legal claim to their land, the woodchoppers felt free to move in and take what they wanted. One helpless victim stood by while workmen raided his cottonwoods. Another squatter resisted, holding off his adversaries with a pistol and a shotgun. But there was little stopping the "hordes," as historian Robert Athearn called them, from sending all available trees to the many sawmills and locomotives of the Union Pacific.[41]

A major problem for the Union Pacific was that the local and regional supply of wood suitable for crossties failed to meet its needs. Cottonwood offered some compensation for the deficiency, but it was moist and soft and when used as crossties held spikes poorly and soon disintegrated. Until the corporation reached the Medicine Bow Range and other parts of the Rocky Mountains, it had to find alternative sources. Soon it purchased ties from Chicago, Pennsylvania, and New York, paying $3.50 or more for each. Bridge timbers, too, traveled some distance. Lumberjacks reduced the white pine forests of Minnesota, Michigan, and Wisconsin to logs. Sawmills trimmed and shaped the logs into timbers and sent them to lumberyards in Chicago, "nature's metropolis." From there, brokers shipped the timbers into the far West.[42]

As workmen stacked rails in Omaha or ties in Sacramento, as they unloaded locomotives, as mechanics set up the machines and got them running, as the graders and tracklayers built bridges into the mountains and laid ties across the prairies, few people thought about the amazing journey the iron and wood had made. Fewer still likely gave much thought to the amazing places left behind: deep pits and denuded hillsides, fouled streams and smoke-congested valleys, cutover forests and piles of sawdust. But every rail, every timber, every spike, nut, bolt, beam, tie, and wheel embodied a powerful truth. Only in relation to distant environments did the Central Pacific and Union Pacific lay down their track; only through a massive alteration of nature in far-flung places could they push their rails through the American West.

MUSCLES AND MINERALS

The transcontinental railroad's consumption of resources revealed a crucial connection between industry and nature, but that intense hunger was

remarkable for another reason as well. The railroad's use of fuel and materials centered it in an epochal ecological and economic transformation distinguished by humanity's adoption of a new major energy source. On one side of that nineteenth-century transition was an advanced organic economy almost entirely reliant on solar energy as radiated daily through wind, current, and the tissues of living things. On the other side was a modern, mineral-based economy defined by its intensive use of fossilized energy embedded in coal and converted to movement in metal machines.[43]

The advanced organic economy gave rise to the transcontinental railroad. For thousands of years, people had made their living from natural processes closely connected to the sun's energy flows. The sun stimulated plants on which people and other animals depended, and it helped drive the hydrologic cycle, the flow of rivers, the movement of air and ocean water, and thus the currents that conveyed vessels to market. In the late eighteenth century, people began to transform the organic economy. Improvements in agriculture and transportation—roads, wagons, ships, canals—enabled them to amass surplus wealth with which to build new technologies such as railroads. People also used organic economy technologies, processes, materials, and fuels to build the new. Iron locomotives and rails arrived in Sacramento on ships with canvas sails that caught the wind. Trees that became logs, ties, and timbers floated downstream to sawmills. The first locomotives of the Central Pacific and Union Pacific burned wood.[44]

The plant production at the heart of the organic economy also fueled the muscle power and "embodied knowledge" necessary to construct the Central Pacific and Union Pacific railroads. Horses, mules, and oxen metabolized the energy in hay and grain into the kinetic energy of muscle power. In much the same way, men transformed the energy inherent in their food into muscular force. The Central Pacific and Union Pacific required massed mammalian effort, and they employed it in bovine, equine, and human forms.[45]

Although rooted in an organic world, the transcontinental railroad also took shape from the materials, processes, technologies, and fuels of the mineral-based economy. The mining and milling of iron, its industrial transformation into railroad technology, and the operation of locomotives consumed copious amounts of coal. Not only was coal more abundant than wood in parts of the American West such as Wyoming's Red Desert, but it contained more energetic potential per unit of weight. The Union Pacific oriented its operations to coal virtually from the start. The locations of deposits influenced

Grenville Dodge's location of the line, and by 1867, the company was extracting coal from mines at Carbon, Wyoming, for use in the *No. 119* and other engines. The Union Pacific's relatively direct access to the fossil fuel—Carbon was about four miles from its main tracks—gave the company an advantage over its eastward-moving counterpart. The Central Pacific did not have ready access to coal in adequate amounts, and until it acquired the fuel from sources near Evanston, Wyoming, and in the Puget Sound region, it had to rely on wood.[46]

The meeting of the wood-fired *Jupiter* and the coal-burning *No. 119* at Promontory Summit was a striking demonstration of the shift from the advanced organic to the mineral-based economy, but the railroads, like most other industrial operations, did not experience the transition in a simple linear progression. If the organic economy made possible industries such as railroads, then the railroads and other industrial operations intensified, well into the twentieth century, the production and exploitation of muscle power and other organic energy sources. It is a little-known fact that the horse population in the United States and worldwide peaked around 1920. It is a better-known but still underappreciated fact that the use of human labor for muscular force climaxed at almost the same time.[47]

MEN AND MULES

Like iron and wood, the muscles and brains that moved earth and laid track originated in environments near and far. The pastures and ranges of California, Utah, and the Midwest supplied horses and oxen. Homelands around the planet, many of them in ecological turmoil, yielded workmen. The majority of the Central Pacific's employees, for example, came from Guangdong in southeastern China, where population growth and land shortage in the Pearl River delta during the eighteenth and nineteenth centuries compelled people to leave. Many who went to California in search of gold ended up working on the Central Pacific. Irish laborers took jobs on both railroads in the aftermath of a fungal disease that, in the mid-1840s, wreaked havoc on their nation. The fungus destroyed the potato crop, causing a famine that killed a million people and scattered refugees across North America. Portuguese from the Azores and other islands in the eastern Atlantic Ocean experienced some of the same kinds of pressures and disasters as did the Chinese and the Irish. From the 1830s to the 1860s, many islanders escaped by taking jobs on American ships that hunted whales for their blubber and spermaceti oils, which were among

the most valuable of the advanced organic economy's energy sources. The whalers eventually took the Portuguese to California, where the immigrants made their way to the Central Pacific line. A number of Union Pacific workers were veterans of the American Civil War, which uprooted men from local communities and transformed them into a mobile labor force that later headed west. These were just a few of the sources from which the railroads gathered laborers, a massive buildup of muscle and embodied intelligence necessary for construction.[48]

A subsidiary but essential flow of resources from across North America fed the railroads' mammalian workforce. Where grass was unavailable locally, especially in mountains and deserts, supply trains and horse-drawn wagons brought in hay and grain. To feed the survey parties and construction crews, the railroads employed hunters. Bison, among other wildlife, disappeared into the stream of energy that laid iron rails across the West. The railroads also consumed cattle herds that they trailed beside the advancing workmen. Fresh meat was not enough, so contractors shipped in flour, cornmeal, potatoes, dried meat, beans, and sugar. The Chinese preferred a more varied diet, and businessmen supplied them with rice, fish, mushrooms, dried seaweed, bamboo shoots, cabbage, and other fare. And laborers of all sorts consumed large quantities of psychoactive and narcotic substances. Coffee, tea, and tobacco stimulated greater energy in the men, and at the end of the day, alcohol and opium numbed them and diverted their minds from their troubles.[49]

The muscular exertions of the working men would have been much more difficult, if not impossible, without the working women who followed the construction. Prostitutes satisfied one of the most basic of human urges, and housekeepers set up tents, erected crude buildings, and took in boarders. "From four in the morning until midnight this slave of the camp is on her feet," wrote the journalist Cy Warman of the housekeeper. Feeding the workers, nursing their wounds and applying horse liniment to their bruises, making them feel at home, "she is at once a mother to the beardless and a sister of charity to the bearded men." Almost no employees of the Central Pacific or Union Pacific brought their wives. One exception was James Strobridge, the Central Pacific's construction superintendent. Strobridge turned a boxcar into a comfortable home complete with a front porch, and for a part of each day he took refuge there in the company of his wife, their three children, and a caged canary—a bit of genteel, domesticated nature.[50]

From such varied environments, bodies, resources, and social circumstances,

the railroads mobilized considerable muscular power and skill. Between 1866 and 1868, the peak of construction, the Central Pacific at any given time employed from twelve thousand to fourteen thousand workmen, most of them Chinese, and many thousands of horses and oxen. During the same period, the Union Pacific fielded a labor force of comparable size and strength. "At one time we were using at least 10,000 animals," recalled Grenville Dodge, "and most of the time from 8,000 to 10,000 laborers." Massing men, horses, and oxen created a reserve of organic energy that the corporations then unleashed on a sequence of heavy construction tasks. The immediate precedent for such mobilization was the Civil War, in which generals and other officers had commanded thousands of men and draft animals in coordinated movements. Some of the construction supervisors, such as the Union Pacific's Grenville Dodge and Jack Casement, had served in the war, and they adapted their military techniques to the management of horses and men, some of them also war veterans, for the building of the railroad.[51]

Most of the railroads' muscle flexed during the movement of rock and soil. Under the direction of bosses, men and horses rearranged ton upon ton of earth. In gangs of several hundred each, laborers with picks and shovels excavated the material and mounded it into road bed, sometimes in a vivid coordinated movement that caught the attention of observers. "The place is black with laborers; they stand as near together as they can shovel," wrote U.S. Army Captain John Currier upon witnessing construction work on the Union Pacific. It was odd, he observed, "to see five hundred shovels going into the air at one time." In conjunction with the pick and shovel crews, hundreds of horse teams and their drivers pulled plows and scrapers, gouging and pushing the ground into shape. The work went on with great regularity, men and draft animals working in unison. At noon, wrote one journalist, the boss called time: "Every man hears him. The mules hear, and if the scraper is ready to dump, the team will stop instantly and let it fall back. Five minutes later the animals are cooling their feet and quenching their thirst in a running brook."[52]

Muscular and mental effort continued and blood flowed more profusely at cuts and tunnels. Workmen with sledgehammers and hand-held drills bored holes into rock. Then they filled the holes with black powder, lit fuses, and took cover from the explosion and the spray of sharp projectiles. For a time, the Central Pacific and Union Pacific tried a new, fearsome chemical compound, nitroglycerine, but its instability made it prone to accidental explosions and so the railroads limited its use. No matter the compound, blasting took its toll

on life and limb. "A deplorable accident occurred on the Pacific Railroad, near Gold Run, on Monday last," reported the *Auburn Placer Herald*, a California newspaper, on April 24, 1866. Smoldering embers from a previous detonation had ignited the fresh powder that the workmen poured into place. Six died; the "foreman . . . was blown to pieces, and one man was blown fifty feet in the air and one hundred feet from the blast." By such means, the railroad consumed the muscles that built it.[53]

After loosening the rock and soil, men and horses carried it to the many fills that extended across gullies and ravines. At cuts and tunnels, workmen piled soil and rubble into hundreds of small, one-horse dumpcarts, each guided by a man. One after another, the carts then trundled to the advancing fill, where a grade boss directed the placement of the earthen material. Cartload upon cartload cascaded down, creating an embankment across which the tracks would run. Men and horses labored in a coordinated, orderly fashion. "The mules are well trained," wrote Capt. Currier; "they climb up and down the bank, stop at the right place and wait till their load is dumped; then take their place in line and go back to get another." And as co-laborers of men, the four-legged mammals were just as vulnerable to workplace hazards. Too much exertion in hot weather, for example, could kill mules. "Six nice fat ones died in less than an hour today," reported a Union Pacific construction boss one summer. Such losses were an essential feature of the relentless resource consumption that fueled the railroad's drive across the West.[54]

At rivers and at ravines too deep to fill with earth, muscle power, intelligence, and skill erected bridges. Supply trains delivered the timbers, often prefabricated for quick assembly, to the advancing railhead. Draft animals hauled the timbers to the construction site and, in conjunction with human laborers, hoisted them into position. The railroads also used animal power to drive wooden bridge piles. Horses lifted a heavy weight, called a hammer, by means of a cable attached to a tall gin pole. Released, the cable dropped the hammer onto the pile, driving it into the ground. At some places, the railroads used small steam engines connected to winches to raise the hammer. But even these machines required organic energy. Men and horses muscled the steam engine into position, and heat from burning wood boiled the contraption's water into steam.[55]

At last came the laying of track. Supply trains delivered ties, rails, spikes, and other iron hardware close to the end of the line. In rapid, coordinated movements, workmen transferred the material to horse-drawn wagons or to

a horse-drawn flatcar, which lurched forward a short distance to the waiting roadbed and the advancing track. A team of men lifted and bedded the cross-ties. Another group hoisted and placed the thirty-foot rails, bolters clamped the rails together at their joints, and spikers armed with mauls followed, playing "the anvil chorus." Then several hundred tampers equipped with shovels and crowbars leveled the track by raising or lowering the ends of ties and packing earthen ballast around them. Laying track was an elaborate dance, a grand rhythmic movement of muscles and materials. "It is in triple time, three strokes to the spike," wrote one journalist. "There are 10 spikes to a rail, 400 rails to a mile, 1800 miles to San Francisco—21,000,000 times are those sledges to be swung; 21,000,000 times are they to come down with their sharp punctuation before the great work of modern America is complete."[56]

Construction bosses knew their task to be the command of massed mammals, and at times they treated and understood human laborers and draft animals similarly. The Union Pacific's Jack Casement, barely five feet tall but stocky, carried a bullwhip with which to intimidate tracklayers. Similar practices and attitudes prevailed on the Central Pacific, where foremen were known as "China herders." Perhaps the railroad's construction superintendent, James Strobridge, provided the most telling example of the bestialization of human labor. Large, loud, profane, and violent, he dominated workmen, cursing them and hitting them with a pick handle, much as the railroad's mule skinners beat out of their teams every possible ounce of muscular effort. Charles Crocker, one of the Central Pacific's "Big Four" business magnates and a hard man himself, objected to Strobridge's methods. Also known as Bull Crocker, he no doubt believed that men, much like horses, had to be mastered; he just wanted "Stro" to be humane about it. (A popular term for the railroad's Chinese workers, "Crocker's pets," perhaps reflected his sentiments.) Crocker thus implored his construction superintendent: "Don't talk so to the men. They are human creatures. Don't talk so roughly to them." Strobridge—who sometimes referred to himself as a bull—would not have it. "You have got to do it, and you will come to it," he retorted. "You cannot talk to them as though you were talking to gentlemen, because they are not gentlemen. They are about as near brutes as they can get."[57]

In such organic circumstances—and often, in such bestialized terms—the construction of the transcontinental railroad went on, each increment measured not just in inches, feet, yards, and miles but also in the steady accumulation of calloused skin, in metallic vibrations that stung hands, arms, and legs,

and in crushing burdens that swayed backs and that made knees wobble. With iron and the application of muscle and mind, the corporations pounded raw nature into an industrial empire.

By December 1867, the Union Pacific reached Granite Canyon in Wyoming's Black Hills; in April 1868 the tracks crossed the cold, windswept expanse of Sherman Summit, 549 miles from Omaha. The tracklayers then followed the roadbed across Dale Creek Bridge, a breathtakingly tall and flimsy structure that swayed in strong winds and threatened to collapse if trains went too fast. By June they had reached Laramie, at mile 573, one among several stations at which the Union Pacific pumped water from wells by means of enormous windmills. In October, after spending the summer crossing the Red Desert, they arrived in Green River, 845 miles from the starting point. "Every mile of the Union Pacific," the historian Maury Klein wrote, relied "less on machines than on the sweat, stamina, and muscles of the men who built it."[58]

The Central Pacific, meanwhile, continued its ascent toward Donner Pass. In July 1866 the road lay open to Alta, 69 miles from Sacramento. By December the trains had passed through Emigrant Gap and steamed toward Cisco, 92 miles out, 5,911 feet up, and but a short, steep ascent away from the summit. Along the way, laborers excavated through and around a series of forbidding geological formations. At the Bloomer Cut, 63 feet deep and some 800 feet long, they chipped and blasted through conglomerate rock, a kind of natural concrete. The walls of the cut were sheer and clean, almost as if the workmen and their teams had sliced a wedge from a cake or a cheese. Barely wide enough for a train to pass through, the opening reflected the labor that produced it. Because animal power could remove only so much earth in a given period, the narrowest cut was the most economical.[59]

Much farther up in the mountains, the Central Pacific laborers came to Cape Horn, a granite outcrop that jutted some thirty-eight hundred feet above the American River. Rounding Cape Horn, much like rounding its namesake at the tip of South America, was a perilous enterprise. But gradually men and horses excavated a ledge along which they could extend the tracks. The sight of thousands of laborers removing the rock impressed observers. "They are laying siege to Nature in her strongest citadel," wrote one. "Swarms" of Chinese, he added, invoking an insect metaphor popularly applied to massed laborers, especially Asians, "made the rugged mountains look like stupendous anthills."[60]

At last the Central Pacific concentrated the power of muscles and brains on the most daunting phase of the construction—a series of tunnels underneath

Donner Pass. Located 105.5 miles from Sacramento, 1,659 feet long when completed, Summit Tunnel was the most difficult of the bores. In August 1866, well before the arrival of tracks, workmen began excavating at both ends of its planned route. They also began sinking a shaft to the tunnel's projected center point, from which they would then dig outward toward the two openings already under way. To assist the removal of rock, Central Pacific officials decided to position a steam-powered hoist above the shaft. They purchased a small locomotive at Sacramento, hauled it to the end of the track, dismantled it, and then loaded its essentials—firebox, boiler, cylinders, pistons—onto a logging wagon pulled by ten yoke of oxen and driven by a teamster known as Missouri Bill. Straining under Missouri Bill's lashes and curses, the oxen freighted the engine—which the colorful teamster dubbed the *Black Goose*—across the rugged mountain terrain. After six arduous weeks, the engine arrived at the shaft. Mechanics then attached it to a drum and cable and put it to work.[61]

Central Pacific officials probably knew even before Missouri Bill and his ox team reached their destination that the *Black Goose* would be useful not just for hoisting rock but also for powering an air compressor that would drive a drill. By such means, the excavations would go faster. But when a mechanic unpacked the newly arrived drill and prepared to assemble it, he ran into trouble. Under no circumstances would Strobridge allow the workman to divert steam to the pneumatic device. Strobridge objected in part because it would interfere with the hoist's capacity to remove rock, but the old bull had another reason for prohibiting the drill. As the writer David Bain noted, Strobridge had spent virtually his entire construction career "supervising human muscle over rock." When it came to drilling, he preferred hand labor to a form of mechanical power that was unproven and perhaps unreliable. In the question of man or machine, Strobridge would not give up the means that was most familiar to him. Crocker and others of the Big Four pleaded with him to reconsider, but Strobridge would have his way. Strong muscles and skilled hands it would be.[62]

BREAKING ROCK, BREAKING BODIES

Humans, however, posed their own problems to construction. As Strobridge certainly knew, they could be as stubborn as mules and as obstinate as granite. Surmounting the rock and snow of Donner Pass required thousands of workmen, but those workmen could thwart progress just as surely as any jagged peak. Keeping them on the job was not easy: laborers might collect their pay and

head off to the next gold strike or land rush. If they stayed, they might object to working conditions or agitate for higher wages. To overcome the mountains, the Central Pacific had to manipulate and control—conquer if necessary—the bodies of workmen.[63]

The Central Pacific reached a turning point in its relations with wageworkers in 1865, when it began to recruit Chinese. Ever the conservative, Strobridge at first had refused to hire Chinese, saying that he would not accept employees who by nature were unsuited to construction tasks. Could little yellow men in pigtails swing mauls, heft stone, guide mules? But after Irishmen approached him to ask for higher wages, he agreed with Crocker that Chinese might be useful after all. By expanding the labor pool with low-paid Chinese, Strobridge could undercut the wage demands of the Irish. The Chinese, for their part, had good reason to take the work. Legally discriminated against, denied entry into the most lucrative gold fields, and indebted for their transportation to California, they might well have seen the $30 per month that the railroad promised them as the best of a limited set of options. By the time Strobridge had some twelve thousand Chinese workers on the payroll, whites were already learning the price of the new dual labor system. Asked about his wages—$35 a month plus board—one Irishman summarized his group's situation. "But if it wasn't for them damned nagurs," he said, "we could get $50 and not do half the work."[64]

Environmental conditions soon upset the stability that the Central Pacific gained from its predominantly Chinese workforce. In 1866–1867, a combination of harsh weather and stubborn rock pushed the railroad and its laborers to the limits of their endurance. Some forty-four winter storms inundated the tracks with foot upon foot of snow. Avalanches buried men. Ox teams hauling supplies floundered. To rouse the exhausted beasts, drivers twisted their tails, sometimes so hard and so often that the tails broke off. Snowplows, some backed by multiple locomotives, penetrated only a foot into compacted drifts. When machines failed, thousands of men armed with shovels removed the white stuff, sending it down mountainsides or pitching it into train cars that carried it away. In places, laborers had to excavate passages under the snow so they could get to construction sites. Many feet below, other tunnelers "lived like moles," according to one report, and they removed rock in eerie twilight during brutal twelve-hour shifts.[65]

When spring came, the arduous work of snow and rock removal continued. Hoping to attract additional labor, Crocker increased the wages of the Chinese to $35 a month, but this raise came nowhere near the fewer hours, greater pay,

and board that the remaining white workers, by now most of them foremen, received. Even the horses did better; according to one calculation, monthly feed for one animal in the mountains cost $50. As the toll on their bodies mounted, as the energy they expended seemed less equal to the gold and silver coin they received as pay, the Chinese grew less willing to endure their exploitation. By the end of June they could take it no longer, and one morning thousands of them refused to work. To get them back, their leaders told Strobridge, they must have a $40 per month pay standard, a ten-hour day for work above ground, an eight-hour day for tunneling, an end to whipping, and the right to leave the job without harassment.[66]

The demands were unacceptable to the railroad, which the costly mountain environment had driven to the verge of bankruptcy. An outraged Crocker first tried to find an alternative labor force that would undercut the Chinese, and he proposed hiring ten thousand former slaves. (Cotton planters at virtually the same time considered importing Chinese laborers into the South to compete with the freedmen.) But Crocker and Strobridge quickly turned to a far more cunning and effective strategy: they simply stopped the supply trains that carried food to the laborers. By denying the Chinese the organic energy they needed not just to work but to live, the Central Pacific destroyed their collective will. After a week, the hungry, isolated, demoralized strikers gave up and returned to their jobs. Much as the Central Pacific broke the Sierra Nevada granite, so it broke the bodies and spirits of the men it needed to accumulate wealth. Once more did nature give way, once more did capital flow, once more did the line progress.[67]

MACHINES AS THE MEASURE OF MEN

But progress required more than just breaking rock and strikers. It also required the railroads to make their way through the territories of American Indians. When the Central Pacific and Union Pacific advanced across the West, they and their proponents viewed Indians as savages against whom to record the triumph of an industrializing civilization. As the historian Michael Adas has pointed out, European colonizers around the planet pointed to railroads and other technologies as a sign of their superiority over the native peoples they met. They had locomotives, they reasoned, and so they were destined to prevail over the outmoded darker races. Machines, in sum, were the measure of men.[68]

Profound environmental and social turmoil shaped the Indians' responses

to the Pacific railroad. By the 1860s, many Indians across the West, especially some Great Plains peoples, were struggling with a range of problems. Decades of war and epidemics had ravaged their populations. The plants, animals, and landscapes that had sustained them were disappearing as European Americans spread across the continent. The bison herds already were in a downward spiral, victims of anthrax and tuberculosis, competition from horses and other livestock for grass, habitat destruction, drought, and hunting. These ecological disturbances contributed to the outbreak of wars. Indian peoples fought one another for the dwindling buffalo herds and for the diminishing grass that their horses needed, and they struck back at whites. While most tribes lost power in these conflicts, one—the Lakotas—evolved into an imperial nation that conquered neighboring peoples and briefly challenged the U.S. Army on the high plains.

Ecological disturbance and war in turn focused many Indians' attention on the railroad. Members of some Plains Indian tribes raided the Union Pacific for its freight and livestock. In carrying out the attacks, Indian groups asserted power over the United States, and warriors brought honor to themselves. But the raids also had a practical economic purpose. As the historian Pekka Hämäläinen pointed out, Indian raids were "act[s] of resource extraction." For some tribes, raiding the railroad was less a sign of strength than a sign of waning power and incipient dependence on the wealth of European Americans. Not all Indians attacked; for the weakest and most vulnerable, raiding was not an option. These people believed they had no choice but to work for the railroads in exchange for wages.[69]

Arapahos, Cheyennes, and Lakotas frequently raided the Union Pacific as it moved up the Platte Valley into Wyoming. Although the Indians killed and scalped surveyors and members of grading crews, they usually seemed less interested in stopping the railroad and murdering its men than in taking livestock. In May 1867, approximately one hundred Indians surprised a grading camp in western Nebraska, but by the time the graders picked up their rifles, the Indians had fled with "several horses and mules." That same month, Indians killed three men and took thirty-one animals. In July, some three hundred Lakotas besieged eight surveyors in the Red Desert. The Indians killed one man and probably could have wiped out the rest of the party, but they left when they captured the terrified group's stampeding horses. Virtually every attack on the Union Pacific yielded more animals than deaths and sometimes no deaths at all. "Horses, mules, and livestock were run off by the hundreds,

perhaps by the thousands," one business historian concluded, which suggests what the Indians most wanted: animals that brought them wealth, power, and prestige and that could be used as trade items and gifts.[70]

One of the most famous raids took place in August 1867 near Plum Creek, far up the Platte Valley. To avenge a defeat at the hands of the U.S. Army—and to replenish their shrinking resources—a group of Cheyennes decided to plunder a train. "Now the white people have taken all we had and have made us poor and we ought to do something," a man known as Porcupine later recalled his compatriots saying. "In these big wagons that go on this metal road, there must be things that are valuable—perhaps clothing. If we could throw these wagons off the iron they run on and break them open, we should find out what was in them and could take whatever might be useful to us." Under cover of darkness, the raiders loosened a rail, bent it up, and waited. When a locomotive finally came to the twisted rail, the machine "jumped into the air," wrecking the train behind it. The Cheyennes killed and scalped some of the surviving crew, the rest of whom fled into the night. After taking flour, sugar, coffee, tobacco, and clothing, the Indians set fire to the broken cars. The Plum Creek raid brought honor to the men who carried it out, but the raid also occurred just as the bison herds were about to disappear from the central Great Plains and just as the Cheyennes were beginning to suffer from resource deprivation. The Indians' act of counting coup also represented the inception of their dependency on the United States for survival.[71]

Not all Natives resorted to force to get something from the railroad. Indian dependency on European Americans became clearest when people chose not to attack the railroad but to scavenge its waste and work on its behalf. Hungry and desperate, some Indians clung to the fringes of European American settlements, looking for scraps. From such a plight it was but a small step for a few Omaha women to join the crew that graded the roadbed westward from the hardscrabble town that bore their tribal name. Farther up the Platte Valley, recalled Hezekiah Bissell, a civil engineer for the Union Pacific, "Pawnees followed the track-laying camps, living on the kitchen refuse and what they could pick up after the beeves had been dressed." In the face of such poverty, it probably seemed practical to small groups of Pawnee women to pick up shovels for the railroad, and no doubt it made sense to Pawnee men to begin scouting for the army units that guarded the construction crews. The Pawnee scouts were, after all, famished. Bissell watched one group bolt down three days' rations in a single sitting. Moreover, Lakotas and Cheyennes had been their competitors

for land and buffalo—their enemies and victimizers—well before the railroad had made its appearance.[72]

European Americans sometimes recognized Indian dependency as the consequence of hunger rooted in an impoverished landscape, but mostly they interpreted it as yet another sign that their machine-driven civilization was about to overwhelm people who, they believed, still lived a primitive existence. On the basis of that belief, the railroaders and their advocates began to perform rituals and tell tales that for decades shaped a popular mythology of Native people's encounter with the iron horse. Virtually all these dramas centered on a contest between modern machines and Indians. Sometimes the dramas played with the fear that Indians actually might threaten a train, even derail it. But in every case, they concluded with white men and their locomotives triumphant.[73]

In some incidents, European American and American Indian rituals blended in struggles for power and resources. Spotted Tail and seventeen other Lakota Indians appeared one day in 1866 at the Union Pacific construction site as it moved up the Platte Valley. They said they had come to learn how the crews laid track. After showing them the routine and taking them on a tour of the railroad cars, the hosts asked the Lakotas to demonstrate their skill in archery. All but one sent arrows through the hole in a shovel handle at a distance of some sixty feet. When the Lakotas expressed interest in the engines, the crews proposed a race. The Indians lined up on horseback, and at the signal they and the locomotive took off. At first, the horsemen outdistanced the machine, but it soon passed them. As the engineer sped by, he startled the Indians with a blast of the steam whistle, a shrill reminder that machines were the measure of men. The contest over, the Lakotas asked for a meal, and their hosts obliged. Spotted Tail then asked for sacks of flour and quarters of beef, perhaps as tribute, perhaps because his people needed it. When refused, he threatened to return with more warriors and take the food by force. The railroaders responded with curses and counterthreats, and the Lakotas leaped on their horses and rode away.[74]

A central feature of this event—Indians defeated and turned aside by a locomotive—also found expression in popular European American ceremonies, art, and stories. The passage of the 1862 Pacific Railway Act prompted a parade in San Francisco, in which a float bore the legend "Little Indian Boy, Step Out of the Way For the Big Engine." In 1868, a similar motif appeared in a soon-to-be famous Currier and Ives print, *Across the Continent: "Westward the*

Course of Empire Takes Its Way," by the artist Fanny Frances Palmer. Both float and picture depict a locomotive pulling a train out of a frontier settlement and down perfectly straight tracks that pierce the vast wilderness of the American West. Nearby, two mounted Indians recoil from the stream of smoke pouring from the locomotive's stack. The next year, during a private dinner at Promontory that followed the public ceremony, James Campbell, a Central Pacific executive, evoked virtually the same imagery. "Where we now stand," Campbell said in a speech to other railroad officials, "but a few months since could be seen nothing but the path of the red man or the track of the wild deer. Now a thousand wheels revolve and will bear on their axles the wealth of half the world, drawn by the Iron Horse, darkening the landscape with his smoky breath and startling the wild Indian with his piercing scream."[75]

The coming of the Pacific railroad was a hard moment in the lives of many Plains peoples. It is incumbent on students of history to peer into that difficult time and glimpse a reality more complicated than the myth that machines measured the value of men. By wrapping life in a simple story, the myth has hidden the manner in which European Americans, American Indians, and many other kinds of people together experienced the Pacific railroad. It has masked the way the builders assessed their own lives, in relation not to machines but to animals. It has obscured any commonality that might have existed between one man named Porcupine and another with the moniker of Bull. It has veiled the fact that the locomotives of which the railroaders were so proud depended utterly on animals and energy that were central to the Indians' existence. Most of all, it has removed from plain view the ways in which Indians, once rooted in an organic economy, attempted to squeeze the means of life from a modern industrial machine.

TEN MILES IN ONE DAY

The final leg of the journey to Promontory turned into a race. Because the Pacific Railway Act did not specify where, precisely, the tracks would meet, each corporation sought to outdo the other in putting down as many miles as possible. Each mile brought land and loans from the federal government, increased the area from which to generate customers and revenue, hastened the repayment of debts, and minimized the interest on those obligations. The railroads eventually decided on a meeting point, thus ending the race, but until that moment and almost until the tracks joined at Promontory, the westering

star of empire shone down on an intense competition to overcome nature, win land and markets, and accrue wealth.[76]

With the hard winter and spring of 1866–1867 over and with the Chinese workmen's strike broken, the Central Pacific forged ahead. From 1867 to 1868, the corporation removed the last rock from Summit Tunnel and other bores and laid the final rails over Donner Pass. It covered the tracks with some thirty-seven miles of sheds and galleries, embodiments of the Yankee ingenuity that Theodore Judah believed would be necessary to overcome the Sierra Nevada snowfall. Sheds were free-standing structures made of wood beams and topped with slanting, gabled roofs. Galleries abutted the mountainsides and had roofs with one pitch that carried avalanches across the tracks. In spite of their utility and solid construction, the sheds and galleries were not perfect. They reduced the problem of heavy snowfall, but they increased the danger from locomotive fireboxes; the mitigation of one kind of nature exacerbated the hazards of another. The Central Pacific had to install vents on sheds and galleries to rid them of locomotive smoke, but the greater threat was from sparks that escaped the fireboxes and ignited the wooden structures. "For several years the loss from fires was considerable," reported the historian George Kraus, "and several miles of sheds were burned down and had to be rebuilt. In 1870 water trains were installed to fight fires and for sprinkling down the sheds twice a week, thus helping to protect them from fire." Sheds and galleries were important technologies to the Central Pacific, but the railroad had to use them with care.[77]

Even before it completed its summit work, the Central Pacific moved down the east slope. Horses and oxen hauled rails, flatcars, locomotives, and other equipment to the town of Truckee, from which the track advanced along the Truckee River into Nevada. In mid-June 1868, the Central Pacific united the pieces of its transmountain project when the *Antelope* pulled the first passenger train from Sacramento to the new settlement of Reno, Nevada. By then the construction had advanced to the town of Wadsworth, where the tracks soon would head across the Great Basin desert.[78]

In comparison with the Sierra Nevada, that arid landscape offered one important advantage to the Central Pacific—it was a basin-and-range environment, much of it relatively flat and dry, which allowed grading and tracklaying to move at a faster pace. Aside from topography, the desert bestowed no favors. Whereas the Sierra Nevada had timber, building stone, and clean water, the Great Basin offered little more than a grim array of deficits. "There was not a tree that would make a board on over 500 miles of the route, no satisfactory

quality of building stone," and virtually no coal, recalled Lewis Clement, a Central Pacific civil engineer. Precious little forage grew there, especially away from river bottoms. The water that could be found was often salty and mineral laden, and it corroded locomotives and foamed so much that the machines could not use it. The alkaline mixture was just as hard on the mammals unfortunate enough to ingest it. Coffee made from it, wrote Mark Twain, "was the meanest compound man has yet invented." All told, the Great Basin was a poor environment for building a railroad and developing a modern capitalist economy—so poor that in the future the Central Pacific would be unable to sell most of its Nevada land grant. "The country offered nothing," said Clement, summing up its bleakness.[79]

The Chinese laborers' response to the Great Basin intensified the railroad's potential problems in getting across it. The vast salt flats, lunar mountainsides, prickly vegetation, unrelenting sunlight, and bad water were enough to repel anyone not native to the place, including the hardened Chinese. Rumors of murderous Indians and enormous, lethal snakes intensified their anxiety. Hundreds of laborers decided to turn back while they still had a chance, and they grabbed their belongings and fled. Crocker and Strobridge, always in need of a stable workforce, sent men on horseback to round them up. The horsemen "handled these Chinamen like a cowboy would cattle and herded most of them back again," recalled the civil engineer J. M. Graham.[80]

The Central Pacific stubbornly pressed forward, extracting what it could from the land. Cutters transformed the gnarled trunks of juniper trees into stacks of fuel wood. When wells turned up useless alkali water, drillers went to nearby mountain ranges, tapped aquifers, and piped the fresh water across the desert to the tracks.[81]

The Central Pacific also drew Great Basin Indians—Paiute and Shoshone men and women—into its labor force. Corporate officials offered the Indians free passage on the railroad in the hope that this would pacify them. But disease, environmental destruction, and diminishing resources already had knocked out much of their fight. In weakening them, those calamities drove them deeper into the cash economy and closer to the primary agent of its extension into the Great Basin: the Central Pacific Railroad. More important than the free rides on the cars were the railroad's grading jobs. Exchanging muscular effort for pay no doubt represented an opportunity for Indians to reverse their impoverishment and retain a degree of cultural autonomy. But wage work also marked their more direct involvement in a modern economic system from

which few colonized people, once ensnared, ever escaped. Hoping to preserve themselves, Paiutes and Shoshones thus deepened their economic dependence on the railroad as they helped propel it across the desert.[82]

As the Central Pacific sucked in what it could from the Great Basin, it simultaneously mobilized enormous quantities of resources from the Central Valley and Sierra Nevada in California. Then the corporation concentrated all its material power on the advancing railhead. Trains and wagons brought in food, hay, grain, fuel wood, crossties, spikes, rails, tools, and other supplies. Special tank cars—which were flatcars on which the railroad mounted large wooden tanks—delivered water to men, horses, and locomotives.[83]

The railroad made rapid progress. In July 1868, the tracks arrived at Wadsworth, 189 miles from Sacramento. In August the crews reached mile 232 at Humboldt Sink, a stagnant, salty pool in which the Humboldt River abruptly died. Following the Humboldt, the advancing tracks left behind a succession of newly created small towns and supply points: Cold Springs and Rye Patch, Raspberry and Rose Creek, and, on October 1, Winnemucca, 325 miles out. Next came Tule and Golconda, Iron Point and Stone House, Shoshone and Beow-awe; then Cluro, Elko, and Peko. Early in 1869, the tracks reached mile 526 and Humboldt Wells, the headwaters of the river. Despite the fast pace—perhaps in part because of it—the work took its toll. Heat exhaustion felled men and horses. Outbreaks of smallpox and cholera compounded the miseries. Yet the laborers pushed on, and in spring 1869 they entered Utah and the Great Salt Lake Desert, some six hundred miles from Sacramento. Curving along the lakeshore, the railhead advanced toward Promontory, ninety miles away.[84]

While the Central Pacific built across the Great Basin, the Union Pacific tracks passed into Utah and moved through Echo and Weber canyons in the Wasatch Range. Along the route, the railroad overcame bad weather, difficult terrain, striking workers, and shortages of water, crossties, and rails—a full complement of problems that matched or exceeded any that the Central Pacific faced.[85]

In Utah, both Union Pacific and Central Pacific turned to the Mormons—members of the Church of Jesus Christ of Latter-day Saints—for assistance in grading. Mormons participated in the Pacific railroad for much the same reasons other people did: to reverse their ecological misfortunes. Brigham Young, the president of the church, hoped that the railroad would open an avenue of commerce that would bring wealth to Utah, a largely arid landscape of limited biological production, organic energy sources, and economic means. In 1862,

Young purchased shares in the Union Pacific, and in 1865 he joined its board of directors. Three years later, when he contracted with both the Central Pacific and the Union Pacific to grade the Utah portion of the roadbed, he hoped to hasten, and profit from, the railroad's advance into the land that Mormons called Zion. Equally important, he sought much-needed jobs and income for church members. After twenty years of settlement, the Mormon population was growing, arable land was becoming scarce, and drought, along with insects, had destroyed crops. The railroad, Young and other Mormons realized, would remedy their predicament. But by embracing the iron horse, they solved one set of problems only to invite another—the partial loss of their economic autonomy and with it their cherished isolation. For the Mormons, dependency was but a variation on the eternal dilemma of religious idealism: how to live in the world but not be of it.[86]

With the assistance of hundreds of Mormon laborers and horse teams, the two competitors raced through Utah. In December 1868, the Union Pacific tracks arrived at the head of Echo Canyon, 969 miles from Omaha. Weeks later, on January 20, 1869, tracklayers reached an important marker, a solitary evergreen—the 1,000 Mile Tree—at the top of Weber Canyon. From there the crews worked down the rocky gorge toward Ogden, and by March they extended the tracks northwest along the Great Salt Lake. The Central Pacific, meanwhile, followed the lake's north shore, through Kelton and then Monument Point at mile 674. The Promontory Mountains now loomed before both lines.[87]

Besides excavating cuts, raising trestles, and laying track, the Central Pacific and Union Pacific companies had one last obstacle to overcome: deciding on the final meeting place. Where the rails would come together was still an open question. In fact, Mormon graders working in opposite directions had long since passed each other as they prepared lengthy sections of parallel roadbed. Then, in early April, a federal government commission in conjunction with the two corporations settled on Promontory Summit.[88]

The agreement did not stop the competition. Rather, the momentum of the rivalry propelled the two corporations through the remaining miles. Like the final blow on a spike—hit it once more, for good measure—this concluding burst of energy drove home the significance of the first transcontinental railroad.

Charles Crocker wanted to claim the record for miles of track laid in one day. The Union Pacific had set the standard—eight miles—in October 1868,

and afterward its vice president, Thomas Durant, wagered Crocker $10,000 that the Central Pacific could not do better. Now, as the tracklayers neared Promontory, Crocker sensed his opportunity. He devised a tightly coordinated, continuously moving system of machines, muscles, and materials that would roll across the desert. He and Strobridge stockpiled a sufficient quantity of rails, ties, spikes, and other components. They offered quadruple wages if the workmen beat the record, and they waited until the Union Pacific tracks were less than ten miles from the summit, depriving their rival of the opportunity to win back the honor.[89]

Early in the morning of April 28, with Crocker, Strobridge, Durant, Dodge, and other officials looking on, men and horses went to work. All told, some five thousand employees were involved in the operation. Of these, around 850 directly participated in tracklaying. Tie setters, ironmen, levelers, spikers, bolters, and tampers—all worked with precision, each crew, man, and horse performing a specialized task in concert with others.[90]

Some people glimpsed the future in that bustle of activity. "I never saw such organization as that," said a military officer present that day; "it was just like an army marching over the ground and leaving a track built behind them." "These tracklayers are a splendid force," recorded a journalist, "and have been settled and drilled until they move like machinery." The idea of workmen as "human machines," as parts in a mechanism, has appealed to modern scholars predisposed to see the railroad in a progression of technological and industrial development that began with smoking locomotives and ended with robots and rockets. Each laborer involved in the tracklaying, wrote one historian a century later, "was an important cog in the smooth-working machinery."[91]

Yet to describe that moment in terms of subsequent events obscures the organic nature of the first transcontinental railroad. The Central Pacific on April 28, 1869, did push its tracks forward into the blue sky and bright sunshine of a dynamic American republic. But tracks run in two directions, and the same rails that ascended the grade toward Promontory and an industrial future also led backward to a vital organic past. That older world—pungent with the smell of manure, sweat, and wood smoke, resonant with curses, grunts, and the sound of hooves—relied on the strength of mammals more than on the mechanical productions of engineers. It was a brute force world in which muscles still mattered, a world not of human machines but of iron horses.[92]

By one-thirty that afternoon, when the whistle blew for a one-hour dinner break, the Central Pacific had made six miles. After eating and resting,

the horses went back to their positions, the men picked up tools and materials, and again they all moved, yard after yard, a relentless metabolizing collectivity. Water wagons and workmen with buckets of lukewarm tea followed, ready to slake a thirst that only straining bodies could generate. Because the rhythm of daylight and darkness structured the workday, at dusk the whistle sounded for the last time. Cheers from the exhausted laborers confirmed the victory: 10 miles and 56 feet. Together, the men and teams had placed approximately 21,100 ties, laid 3,520 rails—1,056 tons total—and hammered some 84,500 spikes. Ten miles and a thousand tons—muscles, not machines, registered the achievement.[93]

Only three days and but a few miles separated the meeting of the Central Pacific and the Union Pacific at Promontory Summit and the future beyond that. The changes that followed the joining of the rails—and the joining of countless other rails across the West—ramified into the twentieth century. The railroads integrated the nation, furthered industrialization, produced enormous amounts of wealth, and brought far-reaching changes to land and life. Among the ecological transformations that the railroads engendered, one of the greatest was the spread of cattle, sheep, and horses into the mountains, deserts, and prairies of the West. Wherever the railroads penetrated, they connected remote pastures to feedlots and slaughterhouses in distant cities, demonstrating again the vital connection between the iron horse and animal flesh.[94] And much as the old organic economy made possible a system centered on coal, so the railroads enabled transitions to new energy forms even more radical in their possibilities. Seven decades after Promontory, scientists comprehended the nature of something too small to see but with an energetic potential of cataclysmic proportions. ★

GALLERY NO. 3

Iron Horses

Historian Richard Orsi said that the railroad "was nailed to the Earth," so closely was it connected to mineral and organic resources. The builders transformed rock, ore, water, trees, wind, and flesh into envirotechnical systems powered by combustion, steam and atmospheric pressures, gravity, and the metabolisms of mammalian bodies. Hasty, muscle-powered construction limited the size of cuts, fills, and tunnels that both modified and conformed to topography. The proximity of cutover forests and wooden snowsheds, beef carcasses and sweating workmen, giant windmills and steaming boilers, charred timbers and glowing fireboxes, horseflesh and iron horses demonstrated how much the railroad was integral to the Earth. A composite of materials, energies, and forces, an agent of geomorphological and ecological change, the railroad—socially, culturally, politically, economically, technologically—was embedded in nature.

3.1 Joining of the rails, Promontory Summit, Utah, May 10, 1869. Note the different smokestack designs of the *Jupiter* (*left*) and *No. 119* (*right*) an indication of the wood-to-coal energy transition under way.

3.2 Horseflesh and iron horses, Promontory Summit, Utah.

3.3 Wind, water, and steam, Union Pacific Railroad, Wyoming.

3.4 Water tank car, Central Pacific Railroad, Winnemucca, Nevada.

3.5 Central Pacific Railroad snow sheds at Summit Station in the Sierra Nevada. Note the forests, stumps, logs, wooden structures, and smoke vents.

3.6 Chinese workmen and fuel wood in the Bloomer Cut, Central Pacific Railroad, California.

3.7 Wood chutes, Central Pacific Railroad, Sierra Nevada.

3.8 Mules, men, and dump carts, Central Pacific Railroad, Sierra Nevada.

3.9 Remains of slaughtered beef cattle, Union Pacific Railroad, Wyoming. Note the tents in the background and the trestle on the horizon.

Nature Study

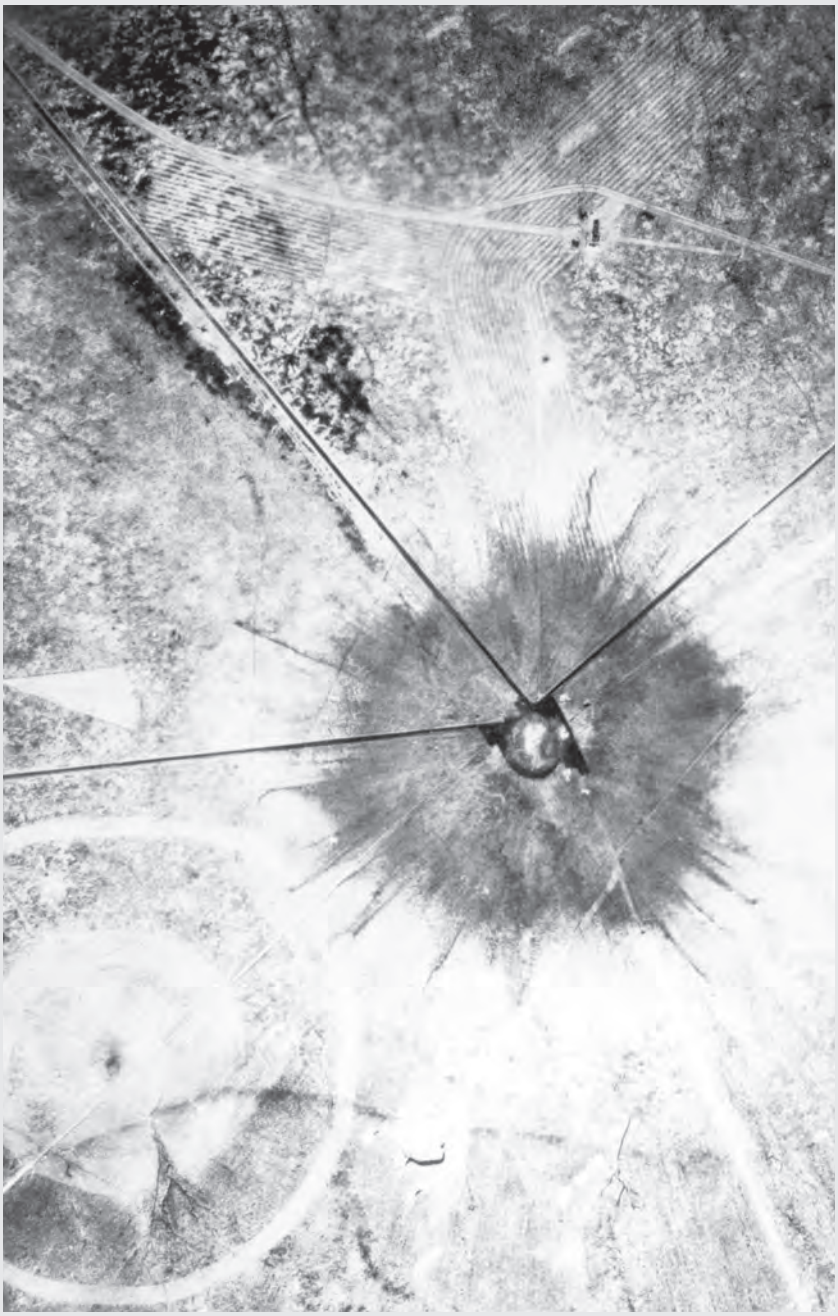
It is axiomatic among many Americans that the experience of nature is essential to the development of well-rounded human beings and citizens. Although no doubt true, the axiom belies the ways that the experience of nature—including childhood nature study—also prepared some people to invent horrifically destructive weapons. The Manhattan Project scientists experienced feelings of awe and wonder when, in the course of their study and research, they confronted the sublime beauty of submicroscopic particles in a cosmos immeasurably large. They took joy in horseback riding, mountain climbing, skiing, and hiking, and in communing with nature on rocky peaks, along streams, in meadows, forests, and deserts, and under the setting sun. As they labored on the bomb, the mountains inspired and consoled them. An aerial view of Trinity Site suggests the physical and moral ambiguity of their work. The blast pattern that radiates from ground zero—like a meteor crater, a sunburst, or a flower—contradicts the linear, instrumental rationality of their military-technological imperatives.

3.10 Albert Einstein in the desert at Palm Springs, California, c. 1930. The physicist Freeman Dyson remarked that the "the chief reward for being a scientist is not the power and the money but the chance of catching a fleeting glimpse of the transcendent beauty of nature."

3.11 Robert Oppenheimer relished grueling horseback rides across undeveloped terrain, one of which he memorialized in the poem "Crossing."

3.12 Manhattan Project scientists in the mountains. *Standing, left to right*, Emilio Segrè, Enrico Fermi, Hans Bethe, Hans Staub, Victor Weisskopf; *seated*, Erika Staub, Elfriede Segrè.

3.13 Niels Bohr, Sawyer's Hill ski run, Los Alamos, New Mexico.



3.14 Trinity Site, July 16, 1945, Alamogordo Bombing Range, Jornada del Muerto, New Mexico.

Natural Hazards

The arrangement of social relationships involved the arrangement of ecologies and landscapes—and vice versa. Nowhere was this truer than in places defined by the creation, maintenance, and evolution of the color line. The color line structured the relationship of racial groups to one another and to the land. Membership in a group influenced if not determined access to resources and spaces derived from the nonhuman natural fundament—sunlight, soil, minerals, water, topography, plants, and animals. Membership in the group also influenced if not determined the hazards to which the color line exposed individual human bodies—human nature, most vulnerably the bodies of children. A tool of social and biophysical containment and control, the color line was the foundational instrument of environmental racism.

3.15 Sandtown, Topeka, Kansas, in the aftermath of the 1903 flood.

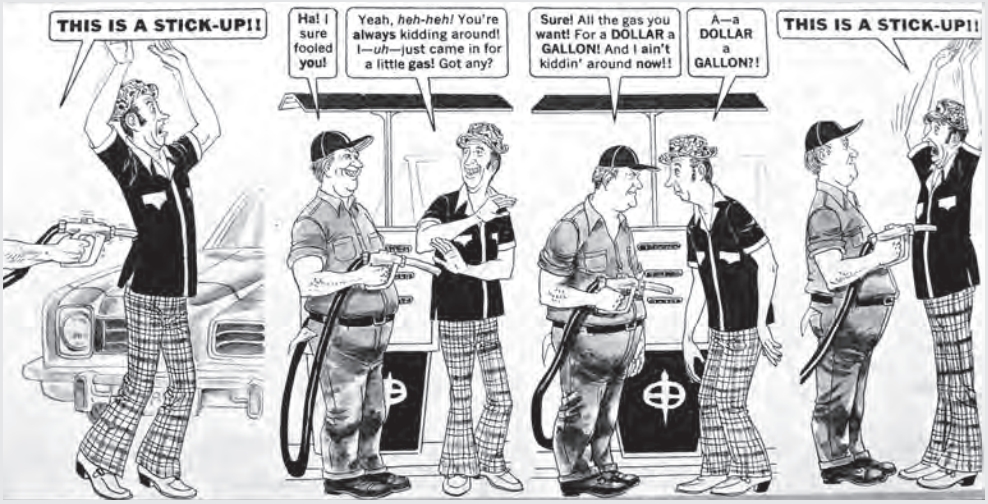
3.16 House and outbuildings, urban renewal area, the Bottoms, Topeka, Kansas, 1961.

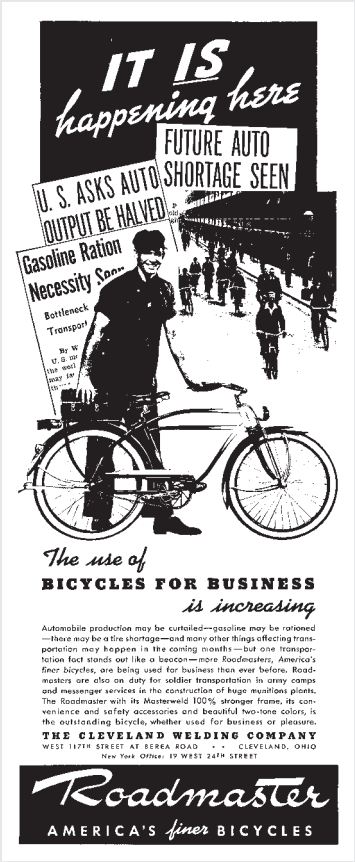
3.17 Nature study. Kindergarten teacher, students, and cotton, Tennesseetown, Topeka, Kansas.

3.18 Linda and Terry Lynn Brown walking to school bus stop, Topeka, Kansas, 1953.

Lipids and Liberty

A fundamental problem for any society is the need to capture a modicum of the energy that streams through the universe. For the republic of nature, the problem is to capture energy sufficient for citizens to realize and conserve their core values of freedom and democracy. The picture of a prostrate Lady Liberty mainlining oil raises troubling questions about the ability of the nation to achieve its purposes. To what extent was the age of democratic revolutions, an age that gave rise to the United States, underwritten by surpluses of food, wood, coal, petroleum, and other energy sources? Is a republic possible without such surpluses? What is the proper equation of energy and liberty? The questions call on scholars, students, and citizens to do the work of environmental history, to look into the nature of the past to find optimal routes into the future.



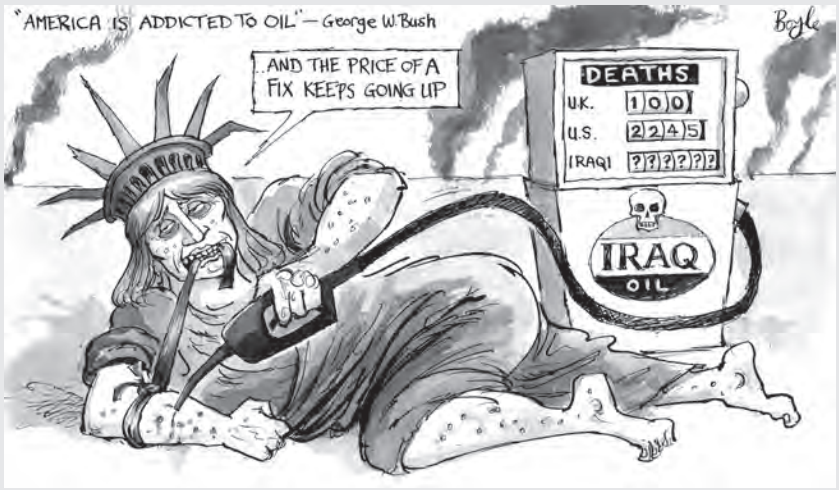


3.19 Dave Berg, "The Lighter Side of the Energy Crisis," *MAD Magazine*, 1974.

3.20 Roadmaster Finer Bicycles, wartime bicycle advertisement, 1941.

3.21 Renting bicycles at a service station in East Potomac Park, Washington, D.C., 1942.

3.22 "All nature is full of God." Matter meets spirit on the entropic highway of the universe, Potlatch, Washington, 1974.



3.23 Addicted to oil, Iraq War. Frank Boyle cartoon.