CHAPTER 1

Into the Silent Sea

In July of 1965, as a tiny octagonal spacecraft swooped across the Martian surface, my father, who had just turned eighteen, was standing tall on a humid, hardwood-forested hill in Appalachia. There on the edge of Viper, Kentucky—below a hundred kilometers of nitrogen and oxygen, under the Kármán line, the exosphere, and the Van Allen belt, beneath the great, vast vacuum of space—a small natural-gas company had sent a bulldozer up a holler and had set about carving out a flat spot for drilling. On the days my father managed to drive the old jeep through the creek bed without flooding the engine, he joined an overalls-clad, illiterate crew in digging ditches and laying pipe, occasionally carrying the casing for the drill head. He'd hoped to spend the summer as a fledgling assistant to the company geologist, but within two weeks, every available worker had been sent to the hillside.

The news about the world's first Mars mission, *Mariner 4,* came by way of *The Courier-Journal,* the newspaper out of Louisville. It arrived on a truck that twisted along the deeply gouged mountain roads, passed the coal camps, passed Hazard High School, and made its way into the small downtown, which was bound like a bobby pin by the North Fork of the Kentucky River.

That morning, my grandfather had picked up the newspaper from Fouts Drug. He'd tucked it under his arm on his way to work at the health department. As a medical technician, he inspected the Cold War–era bomb shelters that dotted the mountain ridges to make sure the food stocks were safe and drew blood to test for syphilis before young couples got married. He took pride in the fact that everyone in town called him "Doc." He wasn't a doctor, but he did give penicillin shots throughout the hills of eastern Kentucky: down in Gilly, up in Typo, in Slemp and Scuddy, in Happy, Yeaddiss, and Busy. When my grandmother wasn't giving perms, she would help out. She liked running the X-ray machine.

It was still muggy later that evening as my grandfather meandered up Broadway—a street that was anything but broad, a single paved lane that fell steeply into backyards teeming with kudzu. He walked into a house that hung like a bat to the side of the ravine, leaving *The Courier-Journal* in the attic bedroom, which was spacious now that four of the six kids had left home. His lanky, wide-eared child, his youngest son, would also leave at the end of the summer, heading two hours west across the steep forested slopes to attend Berea College. My grandfather put the paper on the quilt where my father was sure to find it, next to his *Popular Science* magazine, right beneath a poster of the pockmarked moon.

My father had been spellbound by the idea of the mission, NASA's chance to photograph the planet most similar to Earth. As the mountain town rotated into darkness that Wednesday, my father climbed the steps, aching and exhausted, and he saw the headline. Above the fold, between a picture of Willie Mays and an article on Vietnam, was what he'd been waiting for: MANKIND, THROUGH MARINER, REACHING FOR MARS TODAY. He smiled and fell into bed as he read. "Today the fingertip of mankind reaches out 134 million miles to Mars, almost touching the only other body in the solar system widely suspected of harboring life . . ."

On the other side of the country, in a canyon north of Pasadena, an eager crowd had gathered on the campus of NASA's Jet Propulsion Laboratory. Inside JPL's von Kármán auditorium, intertwined cables, thick and vaguely subterranean, unfurled from a cluster of television cameras and snaked across the floor to the vans outside. Radio from all over the world was hooked in by relay, and the Brits were poised to broadcast a live television feed, having leased a full two minutes of time from the "Early Bird" satellite. There were thirty-seven phones in varying states of use: thirty-six within the press bank, and one sitting atop a desk as part of a small fake office where the TV broadcasters could be filmed.

From floor to ceiling, dominating one side of the great room, was a full-scale spacecraft, one of the flight-ready spares that had been used for temperature-control testing. It had the same octagonal magnesium frame as *Mariner 4,* the same 260 kilograms of hardware and instrumentation. There were 138,000 parts in all: aluminum tubes, attitude-control jets, pyro end cabling. The solar panels, including flaps at the end, stretched seven meters. Coated with sapphire glass, glistening in the beams of the television lights, they looked like the wings of a jeweled pterodactyl.

Much depended on this craft. In a scene that played out repeatedly over the course of the twentieth century, a Soviet spacecraft was approaching Mars at the same time. It had launched from the Baikonur Cosmodrome just two days after *Mariner 4*. It had reached Mars, but, much to NASA's delight, it wouldn't be returning any data. Halfway there, irregular updates had started coming from its communications systems, and then the transmitter died. It was now no more than "the voiceless 'Russian spy,' " "The 'Dead' Soviet Mars missile." At long last, the United States had a chance to pull ahead in the Space Race.

There was only one hurdle standing in the way of American triumph: *Mariner 4* had to aim and actuate the camera and successfully transmit its images back to Earth. This was no easy feat. Mars was so far from the sun that the mission had only 310 watts of usable power, the equivalent of a couple of lightbulbs. The power available to send the data stream would be a mere ten watts to start, which would dissipate to a tenth of a billionth of a billionth of a watt by the time it was captured in the great dishes of the Deep Space Network, the newly built antennas on the outskirts of Johannesburg and Canberra, and deep in the Mojave Desert. And even if the data arrived, there were worries. What if the pictures snapped a bit too early, or a bit too late? What if the spacecraft inadvertently twisted away from the planet at just the wrong moment? What if the camera failed to shut off, recording over the photographs of Mars with pointless photographs of empty space?

The Soviets had been trying to reach Mars for five years. In space exploration as in all things, they were a formidable adversary. In 1960, their first pair of missions had coincided with Premier Nikita Khrushchev's visit to the United Nations General Assembly in New York. He'd commissioned models of the Mars probes and brought them along to show the world. Less than two months earlier, his lead rocket engineer had launched into space the first sentient beings that returned safely to Earth: two dogs, a gray rabbit, forty mice, two rats, and several flies.

But the Soviets were not so lucky this time. As the delegates assembled in New York, the first rocket to Mars failed, climbing just 120 kilometers before falling back to Earth and crashing in eastern Siberia. Then the second rocket failed: A cryogenic leak had frozen the kerosene fuel in the engine inlet. Khrushchev had been relying on another splendid performance from his ambitious young space program and was furious as he paced the halls of the U.N. Before the plenary meeting came to a close, he supposedly went so far as to pull off his shoe, enraged, and brandish it angrily at another country's delegate.

The Soviets tried again with a trio of missions in 1962. The first ruptured in orbit, fanning out debris that was detected by a U.S. radar installation in Alaska. It was nine days into the Cuban Missile Crisis, and the wreckage was momentarily feared by Air Defense Command to be the start of a Soviet nuclear attack. The third also exploded, the main hull of the booster reentering the atmosphere on Christmas Day, followed a month later by the payload. The second, however, traveled 100 million kilometers away from Earth and went on to make the first flyby of Mars—though it was a mute witness to the event, as its transmitter failed, the same thing that happened two years later.

The Soviets kept their defeats to themselves and trumpeted their successes—which were numerous enough to show that they had a decided lead over the Americans. They had reached practically every milestone in the Space Race: the first artificial satellite, the first animal in space, the first man, the first woman. They'd intentionally crashed a spacecraft into the moon and taken the first pictures of its far side, and they were now poised to claim the first spacewalk.

The United States, by contrast, had successfully completed only one planetary mission, *Mariner 2* to Venus. Worse, the Venus mission, the "Mission of Seven Miracles," had barely worked. It was a wonder that it had managed to collect any data at all, flying by the seat of its pants, "limping on one solar panel and heated to within an inch of its life."

And getting to Venus was easier than getting to Mars. To reach the Red Planet, the spacecraft's systems had to stay alive for an extra hundred days, and the data had to be transmitted twice as far. Transistors were new and bulky, and the microchip had just been invented. The computing power of the whole spacecraft was no better than that of a pocket calculator, yet the spacecraft had to rely on a never-before-tested star tracker to point the way. For the first time in history, a NASA probe was drifting into the darkness, traveling away from everything bright in the night—the Earth, the moon, the sun. Just like Coleridge's ancient mariner, it was poised to be "the first that ever burst/Into that silent sea."

Originally, there were to be two *Mariner* missions to Mars: identical-twin spacecraft, nicknamed the "flying windmills." *Mariners 3* and *4* were supposed to zoom by the planet just weeks apart. But the plan went awry when *Mariner 3* was lost within minutes of launch. The rocket, an Atlas-Agena, had performed beautifully, but it soon became apparent that something was amiss. The data coming back from Johannesburg indicated that the spacecraft wasn't on the expected trajectory. The nose fairing, which was designed to protect *Mariner 3* from the crushing force of the launch, hadn't properly detached from the probe. For nine hours, the operations team fought desperately to find some way to rip it off. They tried everything, including firing the spacecraft's motor, but the batteries finally gave way, and *Mariner 3* drifted into a derelict orbit around the sun.

Mars and Earth align on the same side of the sun only once every twenty-six months, so the team had just a few weeks to engineer a solution before Mars moved out of range. The material for the nose fairing had been fabricated and tested under the dense atmospheric pressure of Earth, and they realized that its honeycombed fiberglass skin had started to pop like popcorn in the vacuum of space, expanding enough to wedge the nose fairing tight. The engineers worked around the clock, eventually recognizing that the honeycombed design could be salvaged by poking tiny holes in each cell to equalize the pressure. Just twenty-three days after *Mariner 3* had failed, *Mariner 4* was, improbably enough, ready to launch. It sat on Pad 37 the night before takeoff, shining under the brilliant spotlights. When morning came, it roared forth, lifting off Cape Kennedy on the wings of an Atlas booster. When the rocket released the spacecraft, the nose shield popped right off, just as it was designed to do.

AS *MARINER 4* left Earth's shadow, it began to roll through space. Its first task was to locate distant Canopus, the reference star its onboard sensor would use for navigation. The onboard sensor locked on to Alpha Cephei, far to the north, then moved southward to Regulus, then Zeta Puppis, then an unnamed cluster of three stars. It finally found Canopus, but soon it locked on to a stray light pattern. Then Regulus again. The sensor lost its way no less than forty times throughout its long cruise, as small dust particles and flecks of paint, shining fiercely in the sunlight, kept getting dislodged and falling into the sensor's field of view. The spacecraft stumbled the entire way to Mars, but it survived the 523-million-kilometer journey, circling halfway around the sun. NASA was only seven years old, and this quarter ton of technology was already being heralded as America's greatest achievement in space.

Inside the JPL Space Flight Operations Facility, among the dark-slacked, short-sleeved men with narrow dark ties clipped to the fronts of their shirts, was Bob Leighton, the head of the *Mariner 4* imaging team. That there was an imaging team at all was itself an unlikely development. The prevailing attitude at the time was that photographs were trivial. "Pictures, that's not science. That's just public information," recalled a project manager for NASA's unmanned *Ranger* missions to the moon.

But Leighton had a deep passion for photography. He knew how to render an image, how to bear witness to a pattern of light. He knew what it meant to really *see* something. He'd grown up poor in California—raised by a single mother, who'd made her living as a maid in a Los Angeles hotel. Not long after Leighton graduated, a high school photography teacher found him a job at a photography lab for a Hollywood advertising firm. He could very well have ended up a professional photographer, had his penchant for neatness and efficiency not gotten the best of him. In 1939, he threw out what he thought was a stack of scrap paper, only to discover that it was a client's underexposed blue-light negatives of an elegant steamship sailing under the Golden Gate Bridge. He got his walking papers and returned to L.A. City College. He transferred into the physics department at Caltech his junior year, then never left, joining the faculty in 1949.

Leighton had spent the decade before *Mariner 4* working at the Mount Wilson Observatory. On just a shoestring budget, he'd built an image-stabilization device, a "guider," and taken photos of the planets. He was supposed to be observing stars and galaxies, charting redshifts, making fundamental discoveries about astrophysics—not watching the planets, which were considered too small, cold, and close to reveal much of anything about the nature of the universe. But he couldn't resist catching glimpses now and again. When no one else was around, mostly on holidays like Thanksgiving and Christmas Eve, he'd sneak peeks through the 1.5-meter telescope.

One of Leighton's students had recently been hired by JPL. He told his colleagues about how his former mentor had been able to remove some of the atmospheric turbulence and make movies up at Mount Wilson, beautiful movies, for the first time in color, of a rotating Mars. When an amateurish TV experiment was finally suggested for the mission, the student pleaded with his old professor: "Bob, as a duty to our community, you've got to make a proposal on the TV experiment to Mars. This other one is terrible."

Leighton acquiesced, and within a matter of months, he designed a gizmo with a slow-scan television camera capable of taking twenty-one photographs of Mars over the course of twenty-five minutes. The hope was to collect images of Elysium, then Trivium Charontis, then sweep across Zephyria and into Mare Cimmerium, catching a glimpse of the desert Electis before petering out to the south of Aonius Sinus. For each image, the camera's shutter would click open for a fifth of a second. The pictures would be recorded on a ribbon of magnetic tape, then radioed back to Earth via *Mariner 4*'s high-gain antenna. In a sense, it would be the world's first digital camera.

For decades, the best telescopic observations, on the best of days, had only brought Mars a few times closer than the moon appears to the naked eye. The pictures from Leighton's system on *Mariner 4* would be incalculably better, resolving features as small as 3.2 kilometers across. They would give the world a firsthand view of Mars. Like Martin Luther insisting on a direct relationship with God, the imaging eliminated the need for an interpreter—or "scientific priest," in the words of the youngest member of Leighton's team. The pictures could be spread all over the world for everyone to see, in a language everyone could understand.

But Leighton knew that photographing Mars was more than just an opportunity to share the mission's findings directly with the public. It would be the culmination of a long quest to *see* an entity we'd never encountered, an entity that had puzzled us for centuries. What *was* Mars exactly?

As inconceivable as it sounds, Mars wasn't always understood to be a place. To be sure, the ancients knew there was something intriguing about Mars. The Mesopotamians noticed that it followed a strange loop in the night sky, drifting separately from the "fixed" stars. Everything in the immense night moved together, everything except five little wanderers. Of those, only one appeared as a blazing red lamp. It wasn't only the planet's distinctive color that made it perplexing but also its motion. Mars drifted eastward, night after night, in relation to the other stars, but for about ten weeks every couple of years, it suddenly turned and backpedaled against the zodiac, wandering west for sixty to eighty days before resuming its normal course. In effect, it traced out an elongated loop. Sometimes the size of the loop was smaller, sometimes larger. From this, Plato concluded that the planets had souls, for what could these retrograde acts be, he reasoned, if not expressions of free will?

It wasn't until Galileo looked through a spyglass from a columned terrace in Padua that Mars began its transformation from a glint of light into a world. Within a short stretch of weeks, it became clear to him not only where Mars was in relation to other celestial objects but also *what* it was. Galileo constructed his perspicillum, or telescope, with his own hands. He mounted it on a stand, and because of its tiny field of view, he had to be utterly still, barely breathing, hoping the falling evening temperatures wouldn't cause the glass to mist over. But through its tiny aperture, he determined Mars to be a spherical body illuminated by the sun.

As to whether this body was like the Earth, Galileo was not sure. He hedged in a letter he sent in 1612: "If we could believe with any probability that there were living beings and vegetables on the moon or any planet, different not only from terrestrial ones but remote from our wildest imaginings, I should for my part neither affirm it nor deny it, but should leave the decision to wiser men than I."

The quest to determine the nature of Mars by seeing it better would continue for centuries. When Galileo first looked through his rudimentary telescope, Mars appeared only the size of a poppy seed. But soon concave lenses gave way to convex ones, inverting the image—a minor inconvenience for a much larger field of view. Focal lengths began to grow, and new lenses reduced the optical distortions that Galileo had tried to mitigate with a cardboard washer. In 1659, the Dutch astronomer Christiaan Huygens stuck a telescope out the attic window of his father's large house in The Hague and sketched the first map of Mars. Within a circle, he drew a v-shaped scribble of ink to denote a dark splotch on the planet's surface. In the nights to come, he watched the shadowy blob disappear and reappear. It looked vaguely like an hourglass. It would later be called the Hourglass Sea, the first known surface feature on the planet. After mounting a tiny measuring device to the eyepiece of his rig, he estimated rather accurately that Mars was about 60 percent the size of Earth.

Much to Huygens's surprise, his observations also revealed that the length of the Martian day was roughly twenty-four hours, practically the same as Earth's. These and other similarities between the two planets fueled speculation about Mars's inhabitants. Huygens assumed the presence of intelligent beings, arguing that the planets could not be viewed as "nothing but vast Deserts, lifeless and inanimate Stocks and Stones," for doing so would "sink [the planets] below the Earth in Beauty and Dignity—a thing that no reason will permit." He went so far as to speculate about extraplanetary mathematics, envisioning tables of sines and logarithms, since "there's no reason but the old one, of our being better than all the World, to hinder them from being as happy in their Discoveries, and as ingenious in their Inventions as we ourselves are."

MEANWHILE, AT CAMBRIDGE University, Isaac Newton was developing the basic optics of a new telescope: the reflector. Lenses at the time could not bring red and blue light to the same focus, resulting in a haze of color surrounding bright objects. So instead of a lens, he designed a prototype that collected light by way of a curved metal mirror: six parts copper, two parts tin. It was a tiny instrument, sixteen centimeters long, yielding a magnification of only thirty-five times. Within a century, however, Newton's design would have sweeping implications, enabling unprecedented enlargements of celestial objects. In 1773, William Herschel, a German-born musician living in Bath, England, began experimenting with the construction of mirrors in his spare time. In collaboration with his brilliant younger sister, Caroline, who went on to discover scores of comets and nebulae, he ended up building dozens of reflecting telescopes. From his south-facing garden, he was the first to detect the faint light of Uranus. He also trained his beautifully handcrafted instruments on Mars, revealing that the planet had white polar caps, "clouds and vapors floating in the atmosphere," and seasonal cycles similar to those of the Earth. In 1784, he gave an address to the Royal Society that cast Mars as a kind of copy of the Earth, noting that its inhabitants "probably enjoy a situation in many respects similar to our own." As the observations about the planet continued to roll in, they all fit with the idea of Mars as another Earth, a planet with its own oceans to sail and lands to walk, a place we could recognize, relate to, and imagine.

The idea that Mars was like our planet only drove the quest to see it better. Newton's reflector telescope was soon surpassed, as the speculum metal used for mirrors in large reflecting telescopes was quick to tarnish, and the polishing process often distorted the curve of the mirror. Instead, refracting telescopes, like Huygens's, using two lenses instead of two mirrors, came back into vogue in the nineteenth century. These gradually grew and grew, with lenses so large that gravity began to cause the glass to collapse in on itself. Important discoveries were made, seasonal changes were tracked, moons were discovered. Telescopes, these magical instruments, transported us and let us see what we had never seen before. For hundreds of years, they were our only way to understand Mars.

NOT LONG AFTER I graduated from college, I convinced my father to come with me on a trip into thin desert air. He got on an airplane with me, something he'd only done a few times in his life, and we flew from Kentucky to Atlanta and then on to Tucson. We rented a car and drove deep into Arizona's Old West country, to a hill over a kilometer above the San Pedro River Valley. There was a little hotel, which closed several years ago, at the Vega-Bray Observatory.

We checked in, then went to examine the telescopes. There was a forty-six-centimeter reflector beneath a roll-off roof, a couple of thirty-centimeter Meades, and a half-meter Maksutov-Cassegrain. We zeroed in on a twenty-centimeter Newtonian scope optimized for planetary viewing, which we moved to the observing deck just after dark. There was no tracking system or computer on it, just a sighting mechanism, which was all we needed. My father knew everything about the night sky.

He had spent a good deal of my childhood in the backyard with sky maps from *Astronomy* magazine tucked beneath his elbow. As much as my father would have loved training for a career in geology or astronomy, he'd needed a job to make ends meet, and he'd found one working with the state health department, just like my grandfather had. I'd seen the night sky many times through his oversized binoculars, which invariably wobbled in my hands, even though he always tried to hold them steady for me.

By this point in my life, I'd been to places like Lick Observatory and Mount Wilson Observatory. I'd spent my summers interning at NASA, and I'd visited the giant domes. I'd seen the data that state-of-the-art telescopes could collect flickering on computer screens. But there was something different about seeing the sky through a medium-range telescope at Vega-Bray.

That night in the desert, I sensed for the first time what Galileo and other early astronomers must have felt, something that's been lost in the age of computers. Planetary science used to be an amateur enterprise. Before the dawn of the Space Age, every single practitioner had a direct relationship with the night sky. They were awake when others slept, alone with their science and their thoughts, enveloped by the vast physical world. To point the barrel of a telescope at a tiny dot in the sky and then see it as a world, that dot, that very one right there! Of all the thousand pinpricks of lights, that one is different. That one's threaded by rings. That one has tiny moons, suspended like marbles. That little alabaster hat is a polar cap. That one is a *world*.

Standing there in the cold night air with my father, the telescope at my eye, I felt connected not only to Mars but to Galileo, to Huygens, to Newton, to Herschel. You can't see something like that and not yearn to see it better. As I squinted, making adjustment after adjustment to the dials of the telescope, all I wanted was to fly up to it. Or at least keep the image still. I cursed the atmosphere that wouldn't allow it—the same sky that keeps us alive, brings us rains, and softens our shadows. Even the rarefied air of Arizona tremored and swirled and maddeningly made heavens flicker away. Caught in the grasp of longing and frustration, I could understand why, by the twentieth century, we had to leave our own planet behind.

Two hundred and thirty-one days after *Mariner 4* had launched, on the night of July 15, 1965, the tiny levers of the telex machine at JPL began ferociously clicking. Leighton must have felt a surge of emotion: The *Mariner 4* pictures would be the first ever close-up images of anything beyond the moon, as the mission to Venus hadn't taken any pictures. Leighton poignantly recognized the difference between knowing something about a place and actually seeing it, and so did his imaging team. As Bruce Murray, then only a postdoc, realized, "Looking at a planet for the first time . . . that's not an experience people are likely to have very often in the history of the human race."

The data packets were being flung from Mars to Earth, captured in the huge bowl of the tracking station at Goldstone Space Communications Complex in the Mojave Desert and transmitted across California via teletype to JPL's Voyager Telecommunications section. To Leighton, it seemed that the bits of the picture were like pearls, strung kilometers apart on a string from Earth to Mars. The data rate was only eight and a third bits per second, so it would take eight hours for the first image to be fully transferred. Eight hours of nail-biting, eight hours of pure suspense.

The day before, as *Mariner 4* was approaching Mars, the operations team had decided to relay a command, DC-25, with an updated stretch of code to initiate a platform-scanning action, which would identify the planet, followed by a second command, DC-26, which would ensure the camera stopped and didn't record over the images. The data received before the code was sent suggested that the tape recorder had started and stopped, but there had been some anomalous errors. The tape recorder was also a flight spare, swapped in at the last minute because of a technical problem with the original. It would still be hours, possibly days, before the computers could assemble a real photograph, and now some were second-guessing whether the commands should have been sent, whether they might somehow confuse the computer.

Dick Grumm couldn't stand the wait. He was in charge of the tape recorder, and he and a few other engineers began brainstorming ways they might check the data. It became a contest of sorts, and the winning idea was to print the single-stream data—groups of digits, indicating the brightness of each pixel—onto a reel of ticker tape. As the engineers began snipping the tape into strips and pinning them to the walls, Grumm popped over to a local Pasadena art store in search of six shades of gray chalk, one for each bit of the six-bit image. He ended up with a pack of Rembrandt pastels. "Chalk" was for schools, not artists, he discovered, and anyway, chalk wasn't made in six shades of gray.

Upon his return, a massive paint-by-numbers artwork had been assembled and was now ready to be filled in. The *Mariner 4* image that would eventually be shared with the public was black and white, but Dick's ticker-tape interpretation with colors corresponding to the brightness scale came to life with pastels ranging from light-yellow ochre to burnt umber to Indian red. He had tried a purple color scheme, then a green one. But the red one seemed to best mimic the gray scale. It just happened to mimic the colors of Mars too.

When a jumpy public-relations team got word of what was happening, they went to find Grumm immediately. They didn't want the restless press to seize upon some messy makeshift picture instead of an actual image of the Martian surface. Grumm refused to stop, arguing that this was engineering work, that he simply needed to verify that his tape recorder was working. They let him continue behind a movable partition, guarded by a security officer. But the press did find out, and they began to push into the room: the pencil-and-paper reporters, the television broadcasters, the radio men. With the gaps in the strips, the 200-by-200-pixel square frame was elongated into a rectangle, but soon, the edge of the planet was clear. *Mariner 4* had taken the first close-up picture of Mars.

Even though the image was half planet, half blackness of space, it was still hailed around the world. The largest-circulation French daily printed the first of the final images, once it was rendered by the computer, across five columns of its front page. IT'S MARVELOUS, read the huge banner of *The Evening News* of London. As soon as the picture was placed into the hands of Pope Paul VI, he wrote across it, *vidimus et admirati sumus*—"we saw and we gazed in wonder."

The camera had fog in it and some of the scan lines failed, causing streaks across the frame. "The resolution was awful," recalls JPL engineer John Casani. "You really couldn't see much." But the images would presumably get better as *Mariner 4* came closer and closer to the planet, imaging it as the sun struck the landscape more obliquely, picking up more contrast.

Among the streaks in the first two images, one dark area appeared to be real. It was twenty kilometers wide, shaped somewhat like a W. With the arrival of the third image, other possible features were identified, including a smaller smudge, just three kilometers across. Low hills perhaps? The first three images were released to the press for a quick look. As for interpreting the images, the center director urged patience. He reminded the public that the team's collective human strength was reaching its limits.

Leighton began utilizing some electronic tricks to improve the quality, like erasing the clearly aberrant lines that arose from faulty scanning. But when he got to frame seven, he stopped in his tracks, struggling to believe what he saw. He called Jack James, the mission director, and the then project manager, Dan Schneiderman, into a small, secure room and showed them the tiny Polaroid of the video scope. It wasn't at all what they had expected. They stared at the image in quiet disappointment. Eventually, Schneiderman uttered what they all knew to be true: "Jack, you and I have a twenty-minute jump on the rest of the lab to go out and look for new jobs."

SCARCELY ANYONE HAD been prepared for what frame seven revealed, much less what they saw in the next dozen images. "My God, it's the moon," thought Norm Haynes, one of the systems engineers. There were craters in the image, all perfectly preserved, which meant the planet was in bleak stasis. The crust hadn't been swallowed by the churn of plate tectonics, but, more important, the surface hadn't been worn down by the ebb and flow of water. Preserved craters meant there had been no resurfacing, no aqueous weathering of any kind resembling that of the Earth. As with the moon, it appeared there had never been any significant quantity of liquid water on the surface—no rainfall, no oceans, no streams, no ponds.

Stunned, the *Mariner 4* team didn't publicly release the images for days as they tried to understand the implications of what they were seeing. Finally, they scheduled a press conference. Lyndon Johnson, who had been following the spacecraft closely, hosted it at the White House. Just a few months earlier, he'd made the mission a centerpiece of his inaugural speech, addressing a country still reeling from John F. Kennedy's assassination. He'd asked the crowd to think of their world as it looked from the rocket hurtling into space, how it was like "a child's globe, hanging in space, the continents stuck to its side like colored maps." He asked them to imagine their fellow passengers on a dot of Earth, to realize that we all have but a moment among our companions. Now, with the results of *Mariner 4* in hand, that dot of Earth felt more isolated than ever before.

When Leighton took the podium in the East Room on July 29, two weeks after the flyby, he explained how man's first close-up look at Mars had revealed the fact that large craters covered at least part of the surface. "A profound fact . . ." he said somberly, as his head swayed slightly to the left. He read from his notes about the nearly seventy craters in the images, ranging from five to 125 kilometers in diameter. Leaning into the microphone, he described how the density of their occurrence was "comparable to the densely cratered uplands of the moon." It was "a scientifically startling fact."

Upon seeing the pictures, Lyndon Johnson sighed, "It may be—it may just be—that life as we know it . . . is more unique than many have thought." The mission's instruments also revealed that the air on Mars was terribly thin. The pressure was minuscule—only a few thousandths of the pressure on Earth—which helped explain why the incoming meteors hadn't burned up. The tiny whiff of carbon dioxide that had been detected with a spectrograph from Earth, and had been assumed a trace constituent, turned out to be essentially the entire atmosphere on Mars. The ground temperature was a frigid minus 100 degrees Celsius, and there was no evidence of any kind of protective magnetic field. The images were pockmarked all the way until they fell off the face of the planet.

The reality of the cold, hard, desolate world was beyond anything that scientists had imagined, beyond even the imaginations of the great science-fiction writers. "Craters? Why didn't we think of craters?" Isaac Asimov, upon seeing the *Mariner 4* images, reportedly asked a friend. The possibilities for the planet had disintegrated, our wild imaginings abraded to nothing. Humanity had spent centuries envisioning Mars as similar to the Earth, but Mars was bombarded, blighted, empty. On July 30, *The New York Times* declared, dispiritedly, what those at the press conference had struggled to say for themselves: Mars was probably "a dead planet."