FIGURING

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All of it—the rings of Saturn and my father's wedding band, the underbelly of the clouds pinked by the rising sun, Einstein's brain bathing in a jar of formaldehyde, every grain of sand that made the glass that made the jar and each idea Einstein ever had, the shepherdess singing in the Rila mountains of my native Bulgaria and each one of her sheep, every hair on Chance's velveteen dog ears and Marianne Moore's red braid and the whiskers of Montaigne's cat, every translucent fingernail on my friend Amanda's newborn son, every stone with which Virginia Woolf filled her coat pockets before wading into the River Ouse to drown, every copper atom composing the disc that carried arias aboard the first human-made object to enter interstellar space and every oak splinter of the floorboards onto which Beethoven collapsed in the fit of fury that cost him his hearing, the wetness of every tear that has ever been wept over a grave and the sheen on the beak of every raven that has ever watched the weepers, every cell in Galileo's fleshy finger and every molecule of gas and dust that made the moons of Jupiter to which it pointed, the Dipper of freckles constellating the olive firmament of a certain forearm I love and every axonal flutter of the tenderness with which I love her, all the facts and figments by which we are perpetually figuring and reconfiguring reality—it all banged into being 13.8 billion years ago from a single source, no louder than the

opening note of Beethoven's Fifth Symphony, no larger than the dot levitating over the small *i*, the *I* lowered from the pedestal of ego.

How can we know this and still succumb to the illusion of separateness, of otherness? This veneer must have been what the confluence of accidents and atoms known as Dr. Martin Luther King, Jr., saw through when he spoke of our "inescapable network of mutuality," what Walt Whitman punctured when he wrote that "every atom belonging to me as good belongs to you."

One autumn morning, as I read a dead poet's letters in my friend Wendy's backyard in San Francisco, I glimpse a fragment of that atomic mutuality. Midsentence, my peripheral vision—that glory of instinct honed by millennia of evolution—pulls me toward a miraculous sight: a small, shimmering red leaf twirling in midair. It seems for a moment to be dancing its final descent. But no—it remains suspended there, six feet above ground, orbiting an invisible center by an invisible force. For an instant I can see how such imperceptible causalities could drive the human mind to superstition, could impel medieval villagers to seek explanation in magic and witchcraft. But then I step closer and notice a fine spider's web glistening in the air above the leaf, conspiring with gravity in this spinning miracle.

Neither the spider has planned for the leaf nor the leaf for the spider—and yet there they are, an accidental pendulum propelled by the same forces that cradle the moons of Jupiter in orbit, animated into this ephemeral early-morning splendor by eternal cosmic laws impervious to beauty and indifferent to meaning, yet replete with both to the bewildered human consciousness beholding it.

We spend our lives trying to discern where we end and the rest of the world begins. We snatch our freeze-frame of life from the simultaneity of existence by holding on to illusions of

permanence, congruence, and linearity; of static selves and lives that unfold in sensical narratives. All the while, we mistake chance for choice, our labels and models of things for the things themselves, our records for our history. History is not what happened, but what survives the shipwrecks of judgment and chance.

Some truths, like beauty, are best illuminated by the sidewise gleam of figuring, of meaning-making. In the course of our figuring, orbits intersect, often unbeknownst to the bodies they carry—intersections mappable only from the distance of decades or centuries. Facts crosshatch with other facts to shade in the nuances of a larger truth—not relativism, no, but the mightiest realism we have. We slice through the simultaneity by being everything at once: our first names and our last names, our loneliness and our society, our bold ambition and our blind hope, our unrequited and part-requited loves. Lives are lived in parallel and perpendicular, fathomed nonlinearly, figured not in the straight graphs of "biography" but in many-sided, many-splendored diagrams. Lives interweave with other lives, and out of the tapestry arise hints at answers to questions that raze to the bone of life: What are the building blocks of character, of contentment, of lasting achievement? How does a person come into self-possession and sovereignty of mind against the tide of convention and unreasoning collectivism? Does genius suffice for happiness, does distinction, does love? Two Nobel Prizes don't seem to recompense the melancholy radiating from every photograph of the woman in the black laboratory dress. Is success a guarantee of fulfillment, or merely a promise as precarious as a marital vow? How, in this blink of existence bookended by nothingness, do we attain completeness of being?

There are infinitely many kinds of beautiful lives.

So much of the beauty, so much of what propels our pursuit of truth, stems from the invisible connections—between ideas, between disciplines, between the denizens of a particular time and a particular place, between the interior world of each pioneer and the mark they leave on the cave walls of culture, between faint figures who pass each other in the nocturne before the torchlight of a revolution lights the new day, with little more than a half-nod of kinship and a match to change hands.

1

ONLY THE DREAMER WAKES

This is how I picture it:

A spindly middle-aged mathematician with a soaring mind, a sunken heart, and bad skin is being thrown about the back of a carriage in the bone-hollowing cold of a German January. Since his youth, he has been inscribing into family books and friendship albums his personal motto, borrowed from a verse by the ancient poet Perseus: “O the cares of man, how much of everything is futile.” He has weathered personal tragedies that would level most. He is now racing through the icy alabaster expanse of the countryside in the precarious hope of averting another: Four days after Christmas and two days after his forty-fourth birthday, a letter from his sister has informed him that their widowed mother is on trial for witchcraft—a fact for which he holds himself responsible.

He has written the world’s first work of science fiction—a clever allegory advancing the controversial Copernican model of the universe, describing the effects of gravity decades before Newton formalized it into a law, envisioning speech synthesis centuries before computers, and presaging space travel three hundred years before the Moon landing. The story, intended to

counter superstition with science through symbol and metaphor inviting critical thinking, has instead effected the deadly indictment of his elderly, illiterate mother.

The year is 1617. His name is Johannes Kepler—perhaps the unluckiest man in the world, perhaps the greatest scientist who ever lived. He inhabits a world in which God is mightier than nature, the Devil realer and more omnipresent than gravity. All around him, people believe that the sun revolves around the Earth every twenty-four hours, set into perfect circular motion by an omnipotent creator; the few who dare support the tendentious idea that the Earth rotates around its axis while revolving around the sun believe that it moves along a perfectly circular orbit. Kepler would disprove both beliefs, coin the word *orbit,* and quarry the marble out of which classical physics would be sculpted. He would be the first astronomer to develop a scientific method of predicting eclipses and the first to link mathematical astronomy to material reality—the first astrophysicist—by demonstrating that physical forces move the heavenly bodies in calculable ellipses. All of this he would accomplish while drawing horoscopes, espousing the spontaneous creation of new animal species rising from bogs and oozing from tree bark, and believing the Earth itself to be an ensouled body that has digestion, that suffers illness, that inhales and exhales like a living organism. Three centuries later, the marine biologist and writer Rachel Carson would reimagine a version of this view woven of science and stripped of mysticism as she makes *ecology* a household word.

Kepler's life is a testament to how science does for reality what Plutarch's thought experiment known as "the Ship of Theseus" does for the self. In the ancient Greek allegory, Theseus—the founder-king of Athens—sailed triumphantly back to the great city after slaying the mythic Minotaur on Crete. For a thousand years, his ship was maintained in the harbor of Athens as a living trophy and was sailed to Crete

annually to reenact the victorious voyage. As time began to corrode the vessel, its components were replaced one by one —new planks, new oars, new sails—until no original part remained. Was it then, Plutarch asks, the same ship? There is no static, solid self. Throughout life, our habits, beliefs, and ideas evolve beyond recognition. Our physical and social environments change. Almost all of our cells are replaced. Yet we remain, to ourselves, "who" "we" "are."

So with science: Bit by bit, discoveries reconfigure our understanding of reality. This reality is revealed to us only in fragments. The more fragments we perceive and parse, the more lifelike the mosaic we make of them. But it is still a mosaic, a representation—imperfect and incomplete, however beautiful it may be, and subject to unending transfiguration. Three centuries after Kepler, Lord Kelvin would take the podium at the British Association of Science in the year 1900 and declare: "There is nothing new to be discovered in physics now. All that remains is more and more precise measurement." At the same moment in Zurich, the young Albert Einstein is incubating the ideas that would converge into his revolutionary conception of spacetime, irreversibly transfiguring our elemental understanding of reality.

Even the farthest seers can't bend their gaze beyond their era's horizon of possibility, but the horizon shifts with each incremental revolution as the human mind peers outward to take in nature, then turns inward to question its own givens. We sieve the world through the mesh of these certitudes, tautened by nature and culture, but every once in a while—whether by accident or conscious effort—the wire loosens and the kernel of a revolution slips through.

Kepler first came under the thrall of the heliocentric model as a

student at the Lutheran University of Tübingen half a century after Copernicus published his theory. The twenty-two-year-old Kepler, studying to enter the clergy, wrote a dissertation about the Moon, aimed at demonstrating the Copernican claim that the Earth is moving simultaneously around its axis and around the sun. A classmate by the name of Christoph Besold—a law student at the university—was so taken with Kepler's lunar paper that he proposed a public debate. The university promptly vetoed it. A couple of years later, Galileo would write to Kepler that he'd been a believer in the Copernican system himself "for many years"—and yet he hadn't yet dared to stand up for it in public and wouldn't for more than thirty years.

Kepler's radical ideas rendered him too untrustworthy for the pulpit. After graduation, he was banished across the country to teach mathematics at a Lutheran seminary in Graz. But he was glad—he saw himself, mind and body, as cut out for scholarship. "I take from my mother my bodily constitution," he would later write, "which is more suited to study than to other kinds of life." Three centuries later, Walt Whitman would observe how beholden the mind is to the body, "how behind the tally of genius and morals stands the stomach, and gives a sort of casting vote."

While Kepler saw his body as an instrument of scholarship, other bodies around him were being exploited as instruments of superstition. In Graz, he witnessed dramatic exorcisms performed on young women believed to be possessed by demons—grim public spectacles staged by the king and his clergy. He saw brightly colored fumes emanate from one woman's belly and glistening black beetles crawl out of another's mouth. He saw the deftness with which the puppeteers of the populace dramatized dogma to wrest control—the church was then the mass media, and the mass media were as unafraid of resorting to propaganda as they are today.

As religious persecution escalated—soon it would erupt into

the Thirty Years' War, the deadliest religious war in the Continent's history—life in Graz became unlivable. Protestants were forced to marry by Catholic ritual and have their children baptized as Catholics. Homes were raided, heretical books confiscated and destroyed. When Kepler's infant daughter died, he was fined for evading the Catholic clergy and not allowed to bury his child until he paid the charge. It was time to migrate—a costly and trying endeavor for the family, but Kepler knew there would be a higher price to pay for staying:

> I may not regard loss of property more seriously than loss of opportunity to fulfill that for which nature and career have destined me.

Returning to Tübingen for a career in the clergy was out of the question:

> I could never torture myself with greater unrest and anxiety than if I now, in my present state of conscience, should be enclosed in that sphere of activity.

Instead, Kepler reconsidered something he had initially viewed merely as a flattering compliment to his growing scientific reputation: an invitation to visit the prominent Danish astronomer Tycho Brahe in Bohemia, where he had just been appointed royal mathematician to the Holy Roman Emperor.

Kepler made the arduous five-hundred-kilometer journey to Prague. On February 4, 1600, the famous Dane welcomed him warmly into the castle where he computed the heavens, his enormous orange mustache almost aglow with geniality. During the two months Kepler spent there as guest and apprentice, Tycho was so impressed with the young astronomer's theoretical ingenuity that he permitted him to analyze the celestial observations he had been guarding closely from all

other scholars, then offered him a permanent position. Kepler accepted gratefully and journeyed back to Graz to collect his family, arriving in a retrograde world even more riven by religious persecution. When the Keplers refused to convert to Catholicism, they were banished from the city—the migration to Prague, with all the privations it would require, was no longer optional. Shortly after Kepler and his family alighted in their new life in Bohemia, the valve between chance and choice opened again, and another sudden change of circumstance flooded in: Tycho died unexpectedly at the age of fifty-four. Two days later, Kepler was appointed his successor as imperial mathematician, inheriting Tycho's data. Over the coming years, he would draw on it extensively in devising his three laws of planetary motion, which would revolutionize the human understanding of the universe.

How many revolutions does the cog of culture make before a new truth about reality catches into gear?

Three centuries before Kepler, Dante had marveled in his *Divine Comedy* at the new clocks ticking in England and Italy: "One wheel moves and drives the other." This marriage of technology and poetry eventually gave rise to the metaphor of the clockwork universe. Before Newton's physics placed this metaphor at the ideological epicenter of the Enlightenment, Kepler bridged the poetic and the scientific. In his first book, *The Cosmographic Mystery,* Kepler picked up the metaphor and stripped it of its divine dimensions, removing God as the clockmaster and instead pointing to a single force operating the heavens: "The celestial machine," he wrote, "is not something like a divine organism, but rather something like a clockwork in which a single weight drives all the gears." Within it, "the totality of the complex motions is guided by a single magnetic force." It was not, as Dante wrote, "love that moves the sun and other stars"—it was gravity, as Newton would later formalize this "single magnetic force." But it was Kepler who thus formulated

for the first time the very notion of a force—something that didn't exist for Copernicus, who, despite his groundbreaking insight that the sun moves the planets, still conceived of that motion in poetic rather than scientific terms. For him, the planets were horses whose reins the sun held; for Kepler, they were gears the sun wound by a physical force.

In the anxious winter of 1617, unfigurative wheels are turning beneath Johannes Kepler as he hastens to his mother's witchcraft trial. For this long journey by horse and carriage, Kepler has packed a battered copy of *Dialogue on Ancient and Modern Music* by Vincenzo Galilei, his sometime friend Galileo's father—one of the era's most influential treatises on music, a subject that always enchanted Kepler as much as mathematics, perhaps because he never saw the two as separate. Three years later, he would draw on it in composing his own groundbreaking book *The Harmony of the World,* in which he would formulate his third and final law of planetary motion, known as the harmonic law—his exquisite discovery, twenty-two years in the making, of the proportional link between a planet's orbital period and the length of the axis of its orbit. It would help compute, for the first time, the distance of the planets from the sun—the measure of the heavens in an era when the Solar System was thought to be all there was.

As Kepler is galloping through the German countryside to prevent his mother's execution, the Inquisition in Rome is about to declare the claim of Earth's motion heretical—a heresy punishable by death.

Behind him lies a crumbled life: Emperor Rudolph II is dead—Kepler is no longer royal mathematician and chief scientific adviser to the Holy Roman Emperor, a job endowed with Europe's highest scientific prestige, though primarily tasked with casting horoscopes for royalty; his beloved six-year-old son is dead—"a hyacinth of the morning in the first day of spring" wilted by smallpox, a disease that had barely spared

Kepler himself as a child, leaving his skin cratered by scars and his eyesight permanently damaged; his first wife is dead, having come unhinged by grief before succumbing to the pox herself.

Before him lies the collision of two worlds in two world systems, the spark of which would ignite the interstellar imagination.

In 1609, Johannes Kepler finished the first work of genuine science fiction—that is, imaginative storytelling in which sensical science is a major plot device. *Somnium,* or *The Dream,* is the fictional account of a young astronomer who voyages to the Moon. Rich in both scientific ingenuity and symbolic play, it is at once a masterwork of the literary imagination and an invaluable scientific document, all the more impressive for the fact that it was written before Galileo pointed the first spyglass at the sky and before Kepler himself had ever looked through a telescope.

Kepler knew what we habitually forget—that the locus of possibility expands when the unimaginable is imagined and then made real through systematic effort. Centuries later, in a 1971 conversation with Carl Sagan and Arthur C. Clarke about the future of space exploration, science fiction patron saint Ray Bradbury would capture this transmutation process perfectly: "It's part of the nature of man to start with romance and build to a reality." Like any currency of value, the human imagination is a coin with two inseparable sides. It is our faculty of fancy that fills the disquieting gaps of the unknown with the tranquilizing certitudes of myth and superstition, that points to magic and witchcraft when common sense and reason fail to unveil causality. But that selfsame faculty is also what leads us to rise above accepted facts, above the limits of the possible

established by custom and convention, and reach for new summits of previously unimagined truth. Which way the coin flips depends on the degree of courage, determined by some incalculable combination of nature, culture, and character.

In a letter to Galileo containing the first written mention of *The Dream*'s existence and penned in the spring of 1610—a little more than a century after Columbus voyaged to the Americas—Kepler ushers his correspondent's imagination toward fathoming the impending reality of interstellar travel by reminding him just how unimaginable transatlantic travel had seemed not so long ago:

> Who would have believed that a huge ocean could be crossed more peacefully and safely than the narrow expanse of the Adriatic, the Baltic Sea or the English Channel?

Kepler envisions that once "sails or ships fit to survive the heavenly breezes" are invented, voyagers would no longer fear the dark emptiness of interstellar space. With an eye to these future explorers, he issues a solidary challenge:

> So, for those who will come shortly to attempt this journey, let us establish the astronomy: Galileo, you of Jupiter, I of the moon.

Newton would later refine Kepler's three laws of motion with his formidable calculus and richer understanding of the underlying force as the foundation of Newtonian gravity. In a quarter millennium, the mathematician Katherine Johnson would draw on these laws in computing the trajectory that lands *Apollo 11* on the Moon. They would guide the *Voyager* spacecraft, the first human-made object to sail into interstellar space.

In *The Dream,* which Kepler described in his letter to Galileo

as a "lunar geography," the young traveler lands on the Moon to find that lunar beings believe Earth revolves around them—from their cosmic vantage point, our pale blue dot rises and sets against their firmament, something reflected even in the name they have given Earth: Volva. Kepler chose the name deliberately, to emphasize the fact of Earth's revolution—the very motion that made Copernicanism so dangerous to the dogma of cosmic stability. Assuming that the reader is aware that the Moon revolves around the Earth—an anciently observed fact, thoroughly uncontroversial by his day—Kepler intimates the unnerving central question: Could it be, his story suggests in a stroke of allegorical genius predating Edwin Abbott Abbott's *Flatland* by nearly three centuries, that our own certitude about Earth's fixed position in space is just as misguided as the lunar denizens' belief in Volva's revolution around them? Could we, too, be revolving around the sun, even though the ground feels firm and motionless beneath our feet?

The Dream was intended to gently awaken people to the truth of Copernicus's disconcerting heliocentric model of the universe, defying the long-held belief that Earth is the static center of an immutable cosmos. But earthlings' millennia-long slumber was too deep for *The Dream*—a deadly somnolence, for it resulted in Kepler's elderly mother's being accused of witchcraft. Tens of thousands of people would be tried for witchcraft by the end of the persecution in Europe, dwarfing the two dozen who would render Salem synonymous with witchcraft trials seven decades later. Most of the accused were women, whose inculpation or defense fell on their sons, brothers, and husbands. Most of the trials ended in execution. In Germany, some twenty-five thousand were killed. In Kepler's sparsely populated hometown alone, six women had been burned as witches just a few weeks before his mother was indicted.

An uncanny symmetry haunts Kepler's predicament—it was

Katharina Kepler who had first enchanted her son with astronomy when she took him to the top of a nearby hill and let the six-year-old boy gape in wonderment as the Great Comet of 1577 blazed across the sky.

By the time he wrote *The Dream,* Kepler was one of the most prominent scientists in the world. His rigorous fidelity to observational data harmonized with a symphonic imagination. Drawing on Tycho's data, Kepler devoted a decade and more than seventy failed trials to calculating the orbit of Mars, which became the yardstick for measuring the heavens. Having just formulated the first of his laws, demolishing the ancient belief that the heavenly bodies obey uniform circular motion, Kepler demonstrated that the planets orbit the sun at varying speeds along ellipses. Unlike previous models, which were simply mathematical hypotheses, Kepler discovered the actual orbit by which Mars moved through space, then used the Mars data to determine Earth's orbit. Taking multiple observations of Mars's position relative to Earth, he examined how the angle between the two planets changed over the course of the orbital period he had already calculated for Mars: 687 days. To do this, Kepler had to project himself onto Mars with an empathic leap of the imagination. The word *empathy* would come into popular use three centuries later, through the gateway of art, when it entered the modern lexicon in the early twentieth century to describe the imaginative act of projecting oneself into a painting in an effort to understand why art moves us. Through science, Kepler had projected himself into the greatest work of art there is in an effort to understand how nature draws its laws to move the planets, including the body that moves us through space. Using trigonometry, he calculated the distance between Earth and Mars, located the center of Earth's orbit, and went on to

demonstrate that all the other planets also moved along elliptical orbits, thus demolishing the foundation of Greek astronomy—uniform circular motion—and effecting a major strike against the Ptolemaic model.

Kepler published these revelatory results, which summed up his first two laws, in his book *Astronomia nova—The New Astronomy*. That is exactly what it was—the nature of the cosmos had forever changed, and so had our place in it. "Through my effort God is being celebrated in astronomy," Kepler wrote to his former professor, reflecting on having traded a career in theology for the conquest of a greater truth.

By the time of *Astronomia nova,* Kepler had ample mathematical evidence affirming Copernicus's theory. But he realized something crucial and abiding about human psychology: The scientific proof was too complex, too cumbersome, too abstract to persuade even his peers, much less the scientifically illiterate public; it wasn't data that would dismantle their celestial parochialism, but storytelling. Three centuries before the poet Muriel Rukeyser wrote that "the universe is made of stories, not of atoms," Kepler knew that whatever the composition of the universe may be, its understanding was indeed the work of stories, not of science—that what he needed was a new rhetoric by which to illustrate, in a simple yet compelling way, that the Earth is indeed in motion. And so *The Dream* was born.

Even in medieval times, the Frankfurt Book Fair was one of the world's most fecund literary marketplaces. Kepler attended it frequently in order to promote his own books and to stay informed about other important scientific publications. He brought the manuscript of *The Dream* with him to this safest possible launch-pad, where the other attendees, in addition to being well aware of the author's reputation as a royal mathematician and astronomer, were either scientists themselves or erudite enough to appreciate the story's clever

allegorical play on science. But something went awry: Sometime in 1611, the sole manuscript fell into the hands of a wealthy young nobleman and made its way across Europe. By Kepler's account, it even reached John Donne and inspired his ferocious satire of the Catholic Church, *Ignatius His Conclave.* Circulated via barbershop gossip, versions of the story had reached minds far less literary, or even literate, by 1615. These garbled retellings eventually made their way to Kepler's home duchy.

"Once a poem is made available to the public, the right of interpretation belongs to the reader," young Sylvia Plath would write to her mother three centuries later. But interpretation invariably reveals more about the interpreter than about the interpreted. The gap between intention and interpretation is always rife with wrongs, especially when writer and reader occupy vastly different strata of emotional maturity and intellectual sophistication. The science, symbolism, and allegorical virtuosity of *The Dream* were entirely lost on the illiterate, superstitious, and vengeful villagers of Kepler's hometown. Instead, they interpreted the story with the only tool at their disposal—the blunt weapon of the literal shorn of context. They were especially captivated by one element of the story: The narrator is a young astronomer who describes himself as "by nature eager for knowledge" and who had apprenticed with Tycho Brahe. By then, people far and wide knew of Tycho's most famous pupil and imperial successor. Perhaps it was a point of pride for locals to have produced the famous Johannes Kepler, perhaps a point of envy. Whatever the case, they immediately took the story to be not fiction but autobiography. This was the seedbed of trouble: Another main character was the narrator's mother—an herb doctor who conjures up spirits to assist her son in his lunar voyage. Kepler's own mother was an herb doctor.

Whether what happened next was the product of intentional

malevolent manipulation or the unfortunate workings of ignorance is hard to tell. My own sense is that one aided the other, as those who stand to gain from the manipulation of truth often prey on those bereft of critical thinking. According to Kepler's subsequent account, a local barber overheard the story and seized upon the chance to cast Katharina Kepler as a witch—an opportune accusation, for the barber's sister Ursula had a bone to pick with the elderly woman, a disavowed friend. Ursula Reinhold had borrowed money from Katharina Kepler and never repaid it. She had also confided in the old widow about having become pregnant by a man other than her husband. In an act of unthinking indiscretion, Katharina had shared this compromising information with Johannes's younger brother, who had then just as unthinkingly circulated it around the small town. To abate scandal, Ursula had obtained an abortion. To cover up the brutal corporeal aftermath of this medically primitive procedure, she blamed her infirmity on a spell—cast against her, she proclaimed, by Katharina Kepler. Soon Ursula persuaded twenty-four suggestible locals to give accounts of the elderly woman's sorcery—one neighbor claimed that her daughter's arm had grown numb after Katharina brushed against it in the street; the butcher's wife swore that pain pierced her husband's thigh when Katharina walked by; the limping schoolmaster dated the onset of his disability to a night ten years earlier when he had taken a sip from a tin cup at Katharina's house while reading her one of Kepler's letters. She was accused of appearing magically through closed doors, of having caused the deaths of infants and animals. *The Dream,* Kepler believed, had furnished the superstition-hungry townspeople with evidence of his mother's alleged witchcraft—after all, her own son had depicted her as a sorcerer in his story, the allegorical nature of which eluded them completely.

For her part, Katharina Kepler didn't help her own case.

Prickly in character and known to brawl, she first tried suing Ursula for slander—a strikingly modern American approach but, in medieval Germany, effective only in stoking the fire, for Ursula's well-connected family had ties to local authorities. Then she tried bribing the magistrate into dismissing her case by offering him a silver chalice, which was promptly interpreted as an admission of guilt, and the civil case was escalated to a criminal trial for witchcraft.

In the midst of this tumult, Kepler's infant daughter, named for his mother, died of epilepsy, followed by another son, four years old, of smallpox.

Having taken his mother's defense upon himself as soon as he first learned of the accusation, the bereaved Kepler devoted six years to the trial, all the while trying to continue his scientific work and to see through the publication of the major astronomical catalog he had been composing since he inherited Tycho's data. Working remotely from Linz, Kepler first wrote various petitions on Katharina's behalf, then mounted a meticulous legal defense in writing. He requested trial documentation of witness testimonies and transcripts of his mother's interrogations. He then journeyed across the country once more, sitting with Katharina in prison and talking with her for hours on end to assemble information about the people and events of the small town he had left long ago. Despite the allegation that she was demented, the seventy-something Katharina's memory was astonishing—she recalled in granular detail incidents that had taken place years earlier.

Kepler set out to disprove each of the forty-nine "points of disgrace" hurled against his mother, using the scientific method to uncover the natural causes behind the supernatural evils she had allegedly wrought on the townspeople. He confirmed that Ursula had had an abortion, that the teenaged girl had numbed her arm by carrying too many bricks, that the schoolmaster had lamed his leg by tripping into a ditch, that the butcher suffered

from lumbago.

None of Kepler's epistolary efforts at reason worked. Five years into the ordeal, an order for Katharina's arrest was served. In the small hours of an August night, armed guards barged into her daughter's house and found Katharina, who had heard the disturbance, hiding in a wooden linen chest—naked, as she often slept during the hot spells of summer. By one account, she was permitted to clothe herself before being taken away; by another, she was carried out disrobed inside the trunk to avoid a public disturbance and hauled to prison for another interrogation. So gratuitous was the fabrication of evidence that even Katharina's composure through the indignities was held against her—the fact that she didn't cry during the proceedings was cited as proof of unrepentant liaison with the Devil. Kepler had to explain to the court that he had never seen his stoic mother shed a single tear—not when his father left in Johannes's childhood, not during the long years Katharina spent raising her children alone, not in the many losses of old age.

Katharina was threatened with being stretched on a wheel—a diabolical device commonly used to extract confessions—unless she admitted to sorcery. This elderly woman, who had outlived her era's life expectancy by decades, would spend the next fourteen months imprisoned in a dark room, sitting and sleeping on the stone floor to which she was shackled with a heavy iron chain. She faced the threats with self-possession and confessed nothing.

In a last recourse, Kepler uprooted his entire family, left his teaching position, and traveled again to his hometown as the Thirty Years' War raged on. I wonder if he wondered during that dispiriting journey why he had written *The Dream* in the first place, wondered whether the price of any truth is to be capped at so great a personal cost.

Long ago, as a student at Tübingen, Kepler had read

Plutarch's *The Face on the Moon*—the mythical story of a traveler who sails to a group of islands north of Britain inhabited by people who know secret passages to the Moon. There is no science in Plutarch's story—it is pure fantasy. And yet it employs the same simple, clever device that Kepler himself would use in *The Dream* fifteen centuries later to unsettle the reader's anthropocentric bias: In considering the Moon as a potential habitat for life, Plutarch pointed out that the idea of life in saltwater seems unfathomable to air-breathing creatures such as ourselves, and yet life in the oceans exists. It would be another eighteen centuries before we would fully awaken not only to the fact of marine life but to the complexity and splendor of this barely fathomable reality when Rachel Carson pioneered a new aesthetic of poetic science writing, inviting the human reader to consider Earth from the nonhuman perspective of sea creatures.

Kepler first read Plutarch's story in 1595, but it wasn't until the solar eclipse of 1605, the observations of which first gave him the insight that the orbits of the planets were ellipses rather than circles, that he began seriously considering the allegory as a means of illustrating Copernican ideas. Where Plutarch had explored space travel as metaphysics, Kepler made it a sandbox for real physics, exploring gravity and planetary motion. In writing about the take-off of his imaginary spaceship, for instance, he makes clear that he has a theoretical model of gravity factoring in the demands that breaking away from Earth's gravitational grip would place on cosmic voyagers. He goes on to add that while leaving Earth's gravitational pull would be toilsome, once the spaceship is in the gravity-free "aether," hardly any force would be needed to keep it in motion —an early understanding of inertia in the modern sense, predating by decades Newton's first law of motion, which states that a body will move at a steady velocity unless acted upon by an outside force.

In a passage at once insightful and amusing, Kepler describes the physical requirements for his lunar travelers—a prescient description of astronaut training:

> No inactive persons are accepted . . . no fat ones; no pleasure-loving ones; we choose only those who have spent their lives on horseback, or have shipped often to the Indies and are accustomed to subsisting on hardtack, garlic, dried fish and unpalatable fare.

Three centuries later, the early polar explorer Ernest Shackleton would post a similar recruitment ad for his pioneering Antarctic expedition:

> Men wanted for hazardous journey, small wages, bitter cold, long months of complete darkness, constant danger, safe return doubtful, honor and recognition in case of success.

When a woman named Peggy Peregrine expressed interest on behalf of an eager female trio, Shackleton dryly replied: "There are no vacancies for the opposite sex on the expedition." Half a century later, the Russian cosmonaut Valentina Tereshkova would become the first woman to exit Earth's atmosphere on a spacecraft guided by Kepler's laws.

After years of exerting reason against superstition, Kepler ultimately succeeded in getting his mother acquitted. But the seventy-five-year-old woman never recovered from the trauma of the trial and the bitter German winter spent in the unheated prison. On April 13, 1622, shortly after she was released, Katharina Kepler died, adding to her son's litany of losses. A quarter millennium later, Emily Dickinson would write in a poem the central metaphor of which draws on Kepler's legacy:

> Each that we lose takes part of us;
> A crescent still abides,

Which like the moon, some turbid night,
Is summoned by the tides.

A few months after his mother's death, Kepler received a letter from Christoph Besold—the classmate who had stuck up for his lunar dissertation thirty years earlier, now a successful attorney and professor of law. Having witnessed Katharina's harrowing fate, Besold had worked to expose the ignorance and abuses of power that sealed it, procuring a decree from the duke of Kepler's home duchy prohibiting any other witchcraft trials unsanctioned by the Supreme Court in the urban and presumably far less superstitious Stuttgart. "While neither your name nor that of your mother is mentioned in the edict," Besold wrote to his old friend, "everyone knows that it is at the bottom of it. You have rendered an inestimable service to the whole world, and someday your name will be blessed for it."

Kepler was unconsoled by the decree—perhaps he knew that policy change and cultural change are hardly the same thing, existing on different time scales. He spent the remaining years of his life obsessively annotating *The Dream* with two hundred twenty-three footnotes—a volume of hypertext equal to the story itself—intended to dispel superstitious interpretations by delineating his exact scientific reasons for using the symbols and metaphors he did.

In his ninety-sixth footnote, Kepler plainly stated "the hypothesis of the whole dream": "an argument for the motion of the Earth, or rather a refutation of arguments constructed, on the basis of perception, against the motion of the Earth." Fifty footnotes later, he reiterated the point by asserting that he envisioned the allegory as "a pleasant retort" to Ptolemaic parochialism. In a trailblazing systematic effort to unmoor scientific truth from the illusions of commonsense perception, he wrote:

> Everyone says it is plain that the stars go around the earth while the Earth remains still. I say that it is plain to the eyes of the lunar people that our Earth, which is their Volva, goes around while their moon is still. If it be said that the lunatic perceptions of my moon-dwellers are deceived, I retort with equal justice that the terrestrial senses of the Earth-dwellers are devoid of reason.

In another footnote, Kepler defined gravity as "a power similar to magnetic power—a mutual attraction," and described its chief law:

> The attractive power is greater in the case of two bodies that are near to each other than it is in the case of bodies that are far apart. Therefore, bodies more strongly resist separation one from the other when they are still close together.

A further footnote pointed out that gravity is a universal force affecting bodies beyond the Earth, and that lunar gravity is responsible for earthly tides: "The clearest evidence of the relationship between earth and the moon is the ebb and flow of the seas." This fact, which became central to Newton's laws and which is now so commonplace that schoolchildren point to it as plain evidence of gravity, was far from accepted in Kepler's scientific community. Galileo, who was right about so much, was also wrong about so much—something worth remembering as we train ourselves in the cultural acrobatics of nuanced appreciation without idolatry. Galileo believed, for instance, that comets were vapors of the earth—a notion Tycho Brahe disproved by demonstrating that comets are celestial objects moving through space along computable trajectories after observing the very comet that had made six-year-old Kepler fall in love with astronomy. Galileo didn't merely deny that tides were caused by the Moon—he went as far as to mock Kepler's assertion that they do. "That concept is completely

repugnant to my mind," he wrote—not even in a private letter but in his landmark *Dialogue on the Two Chief World Systems* —scoffing that "though [Kepler] has at his fingertips the motions attributed to the Earth, he has nevertheless lent his ear and his assent to the Moon's dominion over the waters, to occult properties, and to such puerilities."

Kepler took particular care with the portion of the allegory he saw as most directly responsible for his mother's witchcraft trial —the appearance of nine spirits, summoned by the protagonist's mother. In a footnote, he explained that these symbolize the nine Greek muses. In one of the story's more cryptic sentences, Kepler wrote of these spirits: "One, particularly friendly to me, most gentle and purest of all, is called forth by twenty-one characters." In his subsequent defense in footnotes, he explained that the phrase "twenty-one characters" refers to the number of letters used to spell *Astronomia Copernicana.* The friendliest spirit represents Urania— the ancient Greek muse of astronomy, which Kepler considered the most reliable of the sciences:

> Although all the sciences are gentle and harmless in themselves (and on that account they are not those wicked and good-for-nothing spirits with whom witches and fortune-tellers have dealings . . .), this is especially true of astronomy because of the very nature of its subject matter.

When the astronomer William Herschel discovered the seventh planet from the sun a century and a half later, he named it Uranus, after the same muse. Elsewhere in Germany, a young Beethoven heard of the discovery and wondered in the marginalia of one of his compositions: "What will they think of my music on the star of Urania?" Another two centuries later, when Ann Druyan and Carl Sagan compose the Golden Record as a portrait of humanity in sound and image, Beethoven's Fifth

Symphony sails into the cosmos aboard the *Voyager* spacecraft alongside a piece by the composer Laurie Spiegel based on Kepler's *Harmony of the World*.

Kepler was unambiguous about the broader political intent of his allegory. The year after his mother's death, he wrote to an astronomer friend:

> Would it be a great crime to paint the cyclopian morals of this period in livid colors, but for the sake of caution, to depart from the earth with such writing and secede to the moon?

Isn't it better, he wonders in another stroke of psychological genius, to illustrate the monstrosity of people's ignorance by way of the ignorance of imaginary others? He hoped that by seeing the absurdity of the lunar people's belief that the Moon is the center of the universe, the inhabitants of Earth would have the insight and integrity to question their own conviction of centrality. Three hundred fifty years later, when fifteen prominent poets are asked to contribute a "statement on poetics" for an influential anthology, Denise Levertov—the only woman of the fifteen—would state that poetry's highest task is "to awaken sleepers by other means than shock." This must have been what Kepler aimed to do with *The Dream*—his serenade to the poetics of science, aimed at awakening.

In December 1629, Kepler funded the printing of his *Dream* manuscript out of his already shallow pocket and set the type by hand himself. The first six pages took him four months, and then his money ran out. He left his family at their temporary home in Sagan and, already in precarious health, traveled to Leipzig, where he borrowed fifty florins—a substantial amount, about as much as a skilled craftsperson made in a year. He then put on his warmest brown stockings, belted a pistol and a powder flask into his tattered black woolen cloak, and made his way to Nuremberg, where he bought a famished mare as bony

as himself. The two fragile creatures rode a hundred kilometers through the autumn rain to the Bavarian courts in Regensburg, where Kepler would seek permission to sell some Austrian bonds to repay his debt and finish printing *The Dream*. Days after he arrived and settled into an acquaintance's house, now named after him, Kepler came down with an acute illness. Used to frequent attacks of fever and bodily ailments, he paid little mind. Bloodletting was performed to attempt alleviating the symptoms, but he began slipping in and out of consciousness. Pastors were called in.

At noon on November 15, 1630, Johannes Kepler died, six weeks shy of his fifty-ninth birthday. Three days later, as his body was lowered into a grave in the Lutheran churchyard of St. Peter's Gate, a pastor proclaimed: "Blessed are they who hear and preserve the word of God." The Thirty Years' War, waged unblessed and unblessing on the alleged word of God, would soon swallow the cemetery and erase any trace of Kepler's bones.

The night after the funeral, a full moon passed through Earth's shadow in a lunar eclipse governed by eternal forces deaf to human words—fundamental truths of nature, which Kepler had spoken in the native tongue of the universe: mathematics. Three hundred thirty-nine years later, his *Dream* would come true as the first human foot stepped onto the Moon, leaping humankind via a trajectory calculated by his laws.

. . .

The Copernican model was the first major idea to challenge our self-importance. The challenge has taken many guises in the centuries since, as new world orders have been introduced—from evolutionary theory to civil rights to marriage equality,

which society has initially met with antagonism comparable to that shown by the denizens of Kepler's hometown. What is at the center—be it of the universe or of our power structures—must stay at the center, even at the cost of truth. "The same, precisely the same conflicts have always stood as now, with slight shifting of scene & costume," Ralph Waldo Emerson would write in his journal in the middle of the nineteenth century.

Exactly two hundred fifty years after the solar eclipse that first gave Kepler the idea for *The Dream,* a report on the Woman's Rights Convention of 1852 appeared in the *New York Herald*. Its author—a man who vehemently opposed the idea that women were equal to men—wrote that the convention consisted of "old maids, whose personal charms were never very attractive" and women who have "so much virago in their disposition, that nature appears to have made a mistake in their gender—mannish women like hens that crow." His op-ed contained this pinnacle of illogic buoyed by emotional hysteria:

> If it be true that the female sex are equal to the male in point of physical strength and mental power, how is it that from the beginning of the world to the present time, in all ages, in all countries and climes, in every variety of the human species, the male has been predominant, and the female subject politically, socially, and in the family circle? . . . How did woman first become subject to man as she now is all over the world? By her nature—her sex—just as the negro is and always will be, to the end of time, inferior to the white race, and, therefore, doomed to subjection; but happier than she would be in any other condition, just because it is the law of her nature.

In the wake of his mother's witchcraft trial, Kepler made another observation centuries ahead of its time, even ahead of the seventeenth-century French philosopher François Poullain de la Barre's landmark assertion that "the mind has no sex." In

Kepler's time, long before the discovery of genetics, it was believed that children bore a resemblance to their mothers, in physiognomy and character, because they were born under the same constellation. But Kepler was keenly aware of how different he and Katharina were as people, how divergent their worldviews and their fates—he, a meek leading scientist about to turn the world over; she, a mercurial, illiterate woman on trial for witchcraft. If the horoscopes he had once drawn for a living did not determine a person's life-path, Kepler couldn't help but wonder what did—here was a scientist in search of causality. A quarter millennium before social psychology existed as a formal field of study, he reasoned that what had gotten his mother into all this trouble in the first place—her ignorant beliefs and behaviors taken for the work of evil spirits, her social marginalization as a widow—was the fact that she had never benefited from the education her son, as a man, had received. In the fourth section of *The Harmony of the World*—his most daring and speculative foray into natural philosophy—Kepler writes in a chapter devoted to "metaphysical, psychological, and astrological" matters:

> I know a woman who was born under almost the same aspects, with a temperament which was certainly very restless, but by which she not only has no advantage in book learning (that is not surprising in a woman) but also disturbs the whole of her town, and is the author of her own lamentable misfortune.

In the very next sentence, Kepler identifies the woman in question as his own mother and proceeds to note that she never received the privileges he did. "I was born a man, not a woman," he writes, "a difference in sex which the astrologers seek in vain in the heavens." The difference between the fate of the sexes, Kepler suggests, is not in the heavens but in the earthly construction of gender as a function of culture. It was

not his mother's nature that made her ignorant, but the consequences of her social standing in a world that rendered its opportunities for intellectual illumination and self-actualization as fixed as the stars.

2

TO FIND DISMOONED AMONG THE STARDUST

Maria Mitchell is standing in the front parlor of her humble family home at 1 Vestal Street on the island of Nantucket—a place "undecked, unlovely," as she would later write in a poem, but beloved. Beside her, a shiny brass telescope points out through the removed windowpanes. She is too ablaze with excitement to feel the gusts of February freeze rushing in. A glass bowl filled with water hangs overhead, dappling the room with rainbows. Through a piece of smoked glass, she lifts her big brown eyes to the darkening noonday firmament, ready to count the seconds of the eclipse.

Upstairs, a notecard in her neat hand hangs on the door of a former closet, transfigured by her father into a study for the ten Quaker children to share, but in use by Maria alone: "miss mitchell is busy. do not knock."

Twenty-one minutes past noon, on this particularly biting winter Saturday in 1831, a metallic light begins to turn the houses, the hills, the harbor into a living daguerreotype. I imagine someone across the narrow cobblestoned street stopping Beethoven midbar. I imagine a young whaler down in the bay leaning on his harpoon to look up.

A hundred miles north, under the uncanny skies of partially eclipsed Concord, Ralph Waldo Emerson has just buried his beloved young bride, dead of tuberculosis at twenty.

Against the deepening cobalt of the sky, the Moon glides before the sun and carves a slowly slimming crescent. When it settles for a moment into a glowing ring, Maria counts 117 seconds and feels like she is peering down the gun barrel of time, gold-rimmed and eerie.

She is twelve. She is besotted with the splendor of the cosmos and the sturdy certitude of mathematics—a coruscating intellect undimmed by the limitations of her time and place. No woman can vote. No woman can receive a formal education in higher mathematics or astronomy anywhere in the world. No woman has yet been hired by the United States government for any technical job. Maria Mitchell wouldn't live to reap the vote, but she would become many firsts: America's first professional woman astronomer, the first woman admitted into the American Academy of Arts and Sciences, the first woman employed by the government for a "specialized non-domestic skill" as a "computer of Venus"—a one-person GPS performing complex celestial calculations to help sailors navigate the globe.

The year of her ecliptic revelation, the king of Denmark—Europe's supreme patron of the sciences—announced a major astronomical prize: The first person to discover a new telescopic comet would be awarded a gold medal valued at 20 ducats, a fortune. Such a discovery would be no small feat or mere fluke—the patient observer would have to discern a small, blurry, tailless coma of light amid the cosmic wilderness of existing objects, with which he or she must be intimately familiar in order to detect the interloping apparition.

Night after night, year after year, Maria Mitchell would point her steadfast instrument at the nocturne and sweep the skies with quiet systematic passion, searching for a new celestial object against the backdrop of familiar bodies. One autumn

evening in her twenty-ninth year, she would slip out of her parents' dinner party to climb onto the roof and station herself at the telescope, wrapped in what she called her "regimentals"—her uniform of plain Quaker clothing. I imagine this contained young woman surprising herself with a spontaneous gasp when she sees what she saw at half past ten on that first day of October in 1847, before beckoning her father to the roof to show him the momentous speck she had isolated from the vast cosmic background: a new telescopic comet.

What invigorated Maria Mitchell that evening, and what would drive her for the remaining decades of her life, was not the king's medal, nor the luster of worldwide recognition, but the sheer thrill of discovery—the ecstasy of having personally chipped a small fragment of knowledge from the immense monolith of the unknown, that elemental motive force of every sincere scientist.

Despite Maria's reluctance to make the discovery public, her father insisted that they alert the Harvard Observatory. He finally persuaded her by framing it as a patriotic act—she would be claiming a victory not for her ego but for American astronomy, still in its infancy and wholly uncompetitive with the gravitas of European institutions and the millennia of Middle Eastern and Chinese credibility. But nature itself intervened—on this small island so beholden to the elements for its basic operations, stormy weather delayed the postal pickup for two days. By October 3, as Mitchell's announcement was traveling to Harvard, an astronomer in Europe also observed the comet, reported it to the local astronomical authorities, and swiftly claimed the medal.

When the letter from Nantucket arrived on October 7, the president of Harvard instantly recognized in Maria Mitchell's discovery an opportunity to celebrate a first major triumph for American astronomy—and for the still-nascent Harvard, which

terrain of possibility, that makes her dare to believe she can be something other than what her culture tells her she is, and then become what she believes she can? How does something emerge from nothing? It is a question baffling enough to ask about the universe, but simply obtuse to consider about the self—there is no such thing as a self-made person. Maria Mitchell had an uncommon gift for mathematics, yes, and was animated by a quiet obstinacy that allowed her to shoulder the obstacles her culture placed before her. But she was also the product of myriad factors outside her own nature—she grew up in an uncommonly loving family, with an uncommonly erudite mother and an uncommonly present father who treated her like an intellectual peer, in a maritime town where mathematics was not a lofty indulgence in abstraction but a vital practical aid in navigation, in the Quaker faith, which insisted on the equal education of boys and girls, on an isolated island, where long and dreary winter nights turned astronomy into popular entertainment. In the final years of her life, Mitchell would point to her natural proclivity for mathematics and her father's steadfast encouragement as the wellspring of her scientific achievement, but she would add: "The spirit of the place also had much to do with the early bent of my mind in this direction."

Mitchell, who had learned Latin in childhood and was among antebellum America's few astronomers to use Latin texts, must have known the Latin term *genius loci*—"the spirit of a place." Although the modern use of the word "genius" has allocated it to the individual, this original use encodes the indelible role of place in personhood. Comets of chance and tides of circumstance sculpt the shorelines of the self to make us who we are—we can no more claim all credit for our achievement than deflect all blame for our impediments, and it is often difficult to separate the elements of life that make for fortune from those that make for misfortune. Were Mitchell's accidents of birth lucky or unlucky—to have been born a woman, and

brilliant, in the nineteenth century, in a small and secluded whaling community? Would she have reached further, attained more, been happier in another body, in another era, in another place? These are questions impossible to answer without acknowledging what human hubris it is to call one thing accident and another luck in a universe insentient to any of our hopes and fears, to our categories of good and bad. The human mind seems unwilling to wrap itself and its prosthetic of language around the notion of pure impartial probability. We imbue even the word *chance* with a constellation of subjective meanings—chance as serendipity's accomplice, chance as free will's counterpoint, chance as love's other name or a dog's only.

Even Maria Mitchell's basic unit of identity errs on the side of the improbable: Her first name, spelled like my own—for centuries the most common female name in the Christian world—follows not the Spanish pronunciation currently used in English but the traditional Latin one: Mariah / məˈˈrīˈə/. She is named for her mother's favorite writer, Maria Edgeworth—the pioneering Anglo-Irish author of realist children's literature with progressive political under-currents and an edge of science. Edgeworth was one of a handful of women, alongside Joan of Arc, Sappho, and several saints, whom Auguste Comte included in his *Calendar of Great Men*—a landmark cultural biography of 559 world-changing minds, "worthiest of all ages & nations," spanning from Euclid and Pythagoras to Kepler and Galileo to Beethoven and Milton. It was part of Comte's proposal for a "positivist" solar calendar to replace the Gregorian, comprising thirteen months of twenty-eight days, each day named not for a religious saint but for a hero of secular culture—a scientist, poet, philosopher, painter, inventor, explorer.

To name her daughter for Maria Edgeworth was a choice hardly surprising given the self-taught Lydia Mitchell's immense

erudition. She was the only person to have read every book that could be read on Nantucket—from the holdings of the island's two public libraries, at each of which she had worked as a librarian in order to devour their books, to the private collections of the families wealthy enough to afford such a luxury.

Lydia found an intellectual peer in the self-taught astronomer William Mitchell, who had fallen in love with the rings of Saturn at the age of eight, but she also found something rather uncommon for the time—a marriage not of convenience and domestic practicality, but of deep and passionate devotion. William relinquished his admission to Harvard because he couldn't bear to be away from his beloved. Unlike most Nantucket men, who spent the majority of their time on sailing trips, he rarely left his ever-growing family's side for the remainder of their long and loving marriage, taking on a series of odd jobs—schoolmaster, insurance broker, executor of wills, bank clerk, candlemaker—in order to avoid going to sea.

Like Lydia, William had a dual streak of integrity and insurgency. He embraced certain values of the Quaker faith—abolition, education, and equal intellectual opportunities for the sexes. He insisted that his daughters receive the same basic education as his sons, and when one of his girls began exhibiting an aptitude for science greater than that of any of the others, he met her superior natural gifts with commensurate encouragement and opportunity for scholarship. He turned his house into a stop on the Underground Railroad, in which astronomy played a key role—traveling at night, slaves were told to keep the river on one side and follow the Drinking Gourd, an African name for the Big Dipper, for if they kept after the pole star, they would keep themselves moving north. He boycotted slave-harvested cotton by ensuring that, despite the family's meager means, his wife and daughters wore dresses of silk. (Decades later, when Maria became one of America's first

scientific celebrities, many would remark on her "humble black dress," which was in fact made of silk—a vestige of her family's quiet activism. I have wondered whether Marie Curie, famed for her insistence on owning no more than her one black dress, which she wore both on her wedding day and daily at the lab, was aware of this slender thread of lineage to the cultural progenitor who paved the way for women in science.)

When Maria was eight, her father and his cousin Walter Folger—also a cousin of Benjamin Franklin's, and considered the Benjamin Franklin of Nantucket—cofounded the Nantucket Philosophical Institution, one of the first scientific associations in America. At the end of 1831, ten months after Maria's formative eclipse observation, the Institution began admitting women. Most of Europe's scientific institutions were still decades away from such inclusion. London's Royal Society, the Old World's pantheon of science, admitted its first two female members in 1835. Meanwhile, within a year of its founding, the Nantucket Philosophical Institution had as many women members as men. Thirteen-year-old Maria, her sisters, and their mother were among its first female members.

A year after the Philosophical Institution was founded, Nantucket established its first public school. William Mitchell—who had grown up without a formal school on the island, in an era when Quakers were heavily persecuted and excluded from America's handful of existing colleges—was appointed its first principal. Over the next three years, he hired a number of women teachers. When Maria was ten, an article appeared in the *Nantucket Inquirer* praising her father's insistence on educational equality. With an eye to the answer William Mitchell had modeled, the author asked:

> If widening the sphere of knowledge has a direct tendency to enhance the happiness of the recipient, why not have the fountain flow as liberally for the female part of our species as

> for the "rougher sex"? . . . Are the imaginations of women less vivid than men? If not, why should their minds be denied the privilege of contemplating the countless orbs of argent light that roll in silent magnificence through the deep illimitable expanse?

Then, several months before his daughter beheld the eclipse that illuminated her life path, William resigned to found his own private school "for fifty scholars, half of each sex."

But as much as his Quaker faith informed his values of equality, he refused blind dogma and sculpted other Quaker tenets around his own moral sensibilities. Although Quakers considered music morally corrosive, when his daughters smuggled a piano into the house during one of his brief trips, William didn't have the heart to expel it—the instrument stayed. His boldest insurgency was the water-filled glass bowl that sprinkled the front parlor with rainbows whenever it caught a ray of sun—a scandalous sight given the Quaker ban on color. When asked about the bowl, William declared that he used it to study the bipolarity of light—something he made up on the spot in order to render the inventive kaleidoscope acceptable as a scientific instrument rather than an object whose sole purpose was the delight in beauty. He saw the hunger for beauty as inseparable from the search for truth, both indelible pillars of the human spirit. Many years later, Maria would write in her journal:

> I am just learning to notice the different colors of the stars, and already begin to have a new enjoyment. Betelgeuse is strikingly red, while Rigel is yellow. There is something of the same pleasure in noticing the hues that there is in looking at a collection of precious stones, or at a flower-garden in autumn.

She would marvel at the celestial kaleidoscope while sweeping the sky for comets:

her Atheneum tenure, Mitchell was offered the prestigious job of "computer of Venus" for the United States Navy's nascent *Nautical Almanac*—one of only eleven such positions for mathematical astronomers—at the annual salary of $500, fivefold what she earned at the Atheneum. Accepting only on the condition that she could keep her Atheneum librarianship, she went on to hold the Navy position for twenty years.

The Atheneum reference desk was located at the very back of the former Unitarian church housing the institution—Maria Mitchell practically sat at the altar as she helped students find scientific references, recommended good novels to young people, and curated the books to be ordered for the library's holdings. In unpeopled hours, the Atheneum became her private Alexandria as she read the latest works by Europe's most prominent astronomers, taught herself German, and devoured poetry—from Milton to Elizabeth Barrett Browning, whom she would come to admire more than any other living poet. I can picture her tall figure crescented over the Atheneum desk, large brown eyes streaming down a verse, full lips pressed into focus, parting unconsciously every once in a while to mouth a particularly beautiful line.

These were fertile, formative hours—the woman who spent her mornings with Newton and her evenings with Milton would later grow compelled to contemplate the intersection of astronomy and poetry in an essay titled "The Astronomical Science of Milton as Shown in 'Paradise Lost.' " Never published in her lifetime, the piece appeared in 1894 in the sixth volume of *Poet-Lore*—the oldest continuously running poetry journal in the United States, founded in the year of Mitchell's death by two self-described "progressive young Shakespeare scholars who believed in the evolutionary nature of literature": the couple Charlotte Porter and Helen Archibald Clarke. (The latter signed her literary work H.C.P., effectively adopting her partner's last name long before marriage equality.)

Poet-Lore's early years saw the publication of works by Rainer Maria Rilke, Hermann Hesse, and Rabindranath Tagore, as well as the first English translation of Chekhov's *The Seagull*. Mitchell's piece appeared alongside a letter by George Eliot on the loneliness of her chosen path.

Mitchell, who at the end of her life would confide in one of her Vassar students that she would rather have authored a great poem than discovered a comet, wrote:

> Milton, when read in childhood, fastens his Heaven and Hell upon us; we cannot forget them,—we know no other. We see no sunrise without thinking of his lines:—
>
> > "Now morn her rosy steps in th' eastern clime
> > Advancing, sowed the Earth with orient pearl."
> > [. . .]
>
> Read astronomically, Milton may be taken as the poetical historian of the astronomy of his day. The telescope had been known for sixteen years when he was born. Seven planets had been observed. Galileo had made known the existence of the satellites of Jupiter, the belts of Saturn, the inequalities of the moon's surface, and had declared with fear and trembling, which time showed to be well-grounded, the motion of the earth.

At a time when blood was being shed over the heliocentricity that dislodged man from the center of the universe, a time when the notion of galaxies was still far away, Milton championed the Copernican model and imagined "every star perhaps a world." Long before the composition of the sun was discovered, he accurately described its physical structure, "made porous to receive and drink the liquid light." Having visited the aged, totally blind, Inquisition-imprisoned Galileo, Milton made references to him and allusions to his discoveries throughout *Paradise Lost*. Line 650 of Book I—"Space may

produce new Worlds; whereof so rife"—is considered the very first use of the English word *space* to connote the cosmic expanse. Having seen several comets as a boy, Milton—himself entirely blind by the time he composed *Paradise Lost* with the scribal assistance of his daughters—dramatizes his era's superstitions about these astronomical events:

> Satan stood
> Unterrifi'd, and like a comet burn'd,
> That fires the length of Orphiuchus huge,
> In th' Arctic sky, and from his horrid hair
> Shakes pestilence and war.

Mitchell astutely observed:

> If Milton was vastly beyond his age in most respects, he yielded at times to the superstition of the period; or perhaps he did not do so seriously, but only employed it as poetic imagery.

Walt Whitman, born within months of Mitchell, might have preferred to be an astronomer, unburdened by the artifice of poetry and free to revel in the natural poetics of the universe. Late in life, he would wonder in his notebooks: "Is there not something about the moon, some relation or reminder, which no poem or literature has yet caught?" Just as Mitchell was incubating her Milton essay, Whitman wrote in the preface to *Leaves of Grass*:

> The sky of heaven and the orbs, the forests, mountains, and rivers, are not small themes . . . but folks expect of the poet to indicate more than the beauty and dignity which always attach to dumb real objects . . . they expect him to indicate the path between reality and their souls.

Mitchell tempered her praise for Milton's poetic gift and

astronomical prescience by condemning his bifurcation of the soul along gender lines—the poet, she laments, had "failed to make Eve as intelligent and learned as we require that a woman should be in these days." She writes:

> I felt, even when a child, indignant that Milton should represent Eve as so careless of the angel's discourse that she must tend her flowers just at that juncture. The poet thus shows an ignorant and a manoeuvring woman. It seems to me that the childlike Eve should have remained and listened, asked questions, and kept up the dramatic interest.

Mitchell's precocious vision for who Eve could and should be wasn't the function of her parents alone. Growing up, the Mitchell children had learned to echo their father's enthusiastic response to the question of who the greatest scientist of all time was: "Herschel!" To William Mitchell, this meant William Herschel—the great German-English astronomer, discoverer of Uranus, inaugural president of the Royal Astronomical Society. But to Maria, the surname so routinely exclaimed with such veneration is as likely to have meant William's sister, Caroline Herschel—the world's first professional woman astronomer.

Having barely survived typhus fever at the age of eleven, which damaged her left eye and stunted her growth, Caroline Herschel spent the bulk of her ninety-eight years on Earth sweeping the skies with her one good eye—a tiny figure of four feet three inches stationed at the base of a twenty-foot telescope. She arrived at this unexampled post via a path originating at the meeting point of circumstance and choice.

When political unrest seized the Herschel family's native Hanover, Mr. Herschel sent his two sons abroad to England, hoping to save them from being drafted for war. There, Wilhelm changed his name to William. A prodigy at the oboe and violin since the age of fourteen and now a budding composer, he tried his hand at making a living as a musician. Meanwhile, at

home, Caroline's mother deemed her too ugly for marriage and began training her for the life of a domestic servant. The only surviving daughter in a large brood of boys, Caroline would later describe herself as the Cinderella of the family. "I could not bear the idea of being turned into an Abigail or housemaid," she would recall in her memoirs. When her father, to whom Caroline was deeply attached, suffered a fatal stroke just before her seventeenth birthday, she saw no reason to remain in a cold home preparing her for a bleak future. But her mother refused to let her join William in England. William, twelve years older than Caroline and a second father figure, beseeched on her behalf—to no avail. Caroline persisted for months, years. Finally, in a bout of desperation, she knitted two years' worth of stockings for the family to tide them over in her absence—an act of such stubborn determination that her mother relented at last.

Caroline set out for Bath, where she arrived speaking only the few English words she had picked up on the journey, and joined William with the intention of training as a singer so that she could accompany him in concerts. But although she became an accomplished vocalist, her loyalty to William—at that point and ever after—was so great that when she was invited to perform at a prestigious festival, she declined on the grounds that she never wanted to sing in concerts where her brother was not the conductor.

Meanwhile, William had been falling in love with astronomy, and he decided to abandon his career in music. Too poor to afford instruments and too proud to ask for loans, he taught himself to make mirrors and build telescopes. Caroline became his steadfast assistant—for forty-one years. An excellent observer and a poor mathematician, William came to rely on his sister not only for recording his observations but for making the more complex mathematical calculations. During long nights at the telescope, she brought him food and coffee, kept the fire

pave the path she herself had scythed, self-invention between starshine and clay was no metaphor—literally and frequently, her long skirts dragged through the mud as she trekked across a soggy English lawn to catalog the stars through her telescope. In one particularly telling incident Herschel recorded in her diary on New Year's Eve 1783, she rushed out after a cloudy evening to take advantage of a brief window of visibility. Running through the foot-deep melting snow, she slipped and fell on the mechanism employed for rotating the telescope—two butcher's hooks, one of which pierced her leg above the knee, through the fourteen pairs of stockings she wore during winter observation, to the bone. She recounted the incident:

> My brother's call, "Make haste!" I could only answer by a pitiful cry, "I am hooked!" He and the workmen were instantly with me, but they could not lift me without leaving nearly two ounces of my flesh behind.

Herschel bandaged her own wound until a doctor could see her several days later. When he did, he remarked that "if a soldier had met with such a hurt he would have been entitled to six weeks' nursing in a hospital." She concludes the diary entry with matter-of-factness that bespeaks her superhuman devotion to science:

> To make observations with such large machinery, where all around is in darkness, is not unattended with danger, especially when personal safety is the last thing with which the mind is occupied.

Looking back on her life from the fortunate platform of old age, Herschel wrote, "I undertook with pleasure what others might have thought a hardship." In her lifetime, she calculated the locations of some 2,510 nebulae and discovered eight comets—a staggering number for any individual observer.

Comets have transfixed humanity since ancient times. With their unpredictable apparitions tickling our pattern-seeking propensity, our hunger for casual correlations, our primal tendency toward equating unpredictability and randomness with evil, they came to be seen as omens of drought, famine, and bloodshed. Long after astronomy stripped them of such superstitious enchantment, they have continued to exert a pull on the popular imagination. Like holidays, comets—icy clumps of soot and stardust shed by the eternal as emissaries of the ephemeral—serve as anchors of periodicity by which to moor ourselves to the uncertain flow of existence and space out segments of being along the fleeting interlude of life.

As Mary Wollstonecraft lies dying at the age of thirty-eight, having authored the foundational feminist text *A Vindication of the Rights of Woman* five years earlier, one of Caroline Herschel's comets looms overhead. The year Herschel's comet discoveries earn her admission into the Royal Astronomical Society, a baby is born in Missouri. "I came in with Halley's Comet in 1835," the grown man would write in his 1909 autobiography. "It is coming again next year, and I expect to go out with it." And so he does—Halley's comet, which blazes across Earth's skies once every seventy-five to seventy-six years, is visible on November 30, 1835, when Samuel Clemens is born, and again on April 21, 1910, when he dies as Mark Twain. As birthdays temper the delicious illusion of our own inevitability with the hard fact that we were once inconceivable, so comets remind us that the life of the universe operates on cycles independent of and far grander than our own lifespans.

3

WHAT IS LOST AND WHAT IS GAINED

While Maria Mitchell's mathematical calling became apparent when she was still a child and never left her, she slowly matured into another—a thoroughly different calling complementary to the cosmic in its earthliness and its humanistic concern, which she approached with the same rigor and devotion: social reform.

During her tenure at the Atheneum, Mitchell hosted the institution's regular public lectures by itinerant speakers. Among them was Frederick Douglass, who delivered his very first public speech at the island's temple of learning. One August day in 1841, three years after his escape from slavery, a nervous twenty-three-year-old Douglass—the same age as Mitchell—took the podium at the Atheneum and addressed the mixed-race audience of five hundred gathered there for the first Nantucket Anti-Slavery Convention. He proceeded to deliver a speech so electrifying that at its conclusion, the abolitionist William Lloyd Garrison, who was waiting to take the platform next, leapt to his feet, turned to the audience, and exclaimed: "Have we been listening to a thing, a piece of property, or a man?" The chamber of the Great Hall bellowed with a

resounding “A man! A man!”

Four years later, Douglass—whose friendship Mitchell would cherish for the remainder of her life, exerting herself in her final year to travel to a reception given in his honor—would write in his autobiography:

> I prefer to be true to myself, even at the hazard of incurring the ridicule of others, rather than to be false, and incur my own abhorrence. From my earliest recollection, I date the entertainment of a deep conviction that slavery would not always be able to hold me within its foul embrace.

Maria Mitchell echoed this sentiment in her own diary a decade later, as she was doing for women what Douglass was doing for African Americans:

> The best that can be said of my life so far is that it has been industrious, and the best that can be said of me is that I have not pretended to what I was not.

Another formidable mind to take the Atheneum pulpit was Ralph Waldo Emerson. The Sage of Concord had scandalized New England fifteen years earlier by resigning his prestigious position in the Unitarian church over the practice of communion, which he considered idolatrous and uncivilized. A quarter millennium before Emerson, Kepler’s doubts about the same ritual had made him refuse to sign the central Lutheran tenet of faith, known as the Formula of Concord. Since his dramatic exit from the clergy, Emerson had been making his living as a public speaker. When he visited Nantucket for a lecture a few months before Maria Mitchell’s historic comet discovery, she taught him how to use a telescope. He was awed at the sight of a nebula in the constellation Cassiopeia and a double star in Ursa Minor. “The moon comes here as if it was at home, but there is no shade,” he wrote in his diary of

Nantucket—a "place of winds bleak & shelterless & when it blows a large part of the island is suspended in the air & comes into your face & eyes as if it were glad to see you."

Eight years later, Mitchell attended another lecture by Emerson addressing the subject of beauty. That evening, she exulted in her own diary:

> It was like a beam of light moving in the undulatory waves, meeting with occasional meteors in its path; it was exceedingly captivating. It surprised me that there was not only no commonplace thought, but there was no commonplace expression. If he quoted, he quoted from what we had not read; if he told an anecdote, it was one that had not reached us.

In his meteoric lecture, Emerson argued that "beauty is the form under which the intellect prefers to study the world" and quoted Goethe: "The beautiful is a manifestation of secret laws of Nature, which, but for this appearance, had been forever concealed from us."

This notion of beauty as a focal lens for intellectual curiosity was how Mitchell herself saw the universe, and perhaps how every person of genius does. Beauty magnetizes curiosity and wonder, beckoning us to discover—in the literal sense, to uncover and unconceal—what lies beneath the surface of the human label. What we recognize as beauty may be a language for encoding truth, a memetic mechanism for transmitting it, as native to the universe as mathematics—the one perceived by the optical eye, the other by the mind's eye. "Do not wonder at the fair landscape," Emerson exhorted himself in his journal, "but at the necessity of Beauty under which the universe is." In the preface to her translation of *Prometheus Bound,* the twenty-seven-year-old Elizabeth Barrett Browning wrote:

> All beauties, whether in nature or art, in physics or morals, in

required to "contribute her or his proportional share of original composition, in order to carry out one important feature of the Society: the giving of pleasure and profit to every other member." Every Monday, Mitchell herself contributed an original poem. In one, she celebrates the choice not to marry and the rewards of remaining the master of her own time and thought in an era when, still in her twenties, she was already entering spinsterhood:

> There's a deal to be learned in a midnight walk
> When you take it all alone.
> If a gentleman's with you, it's talk, talk, talk.
> You've no eyes and mind of your own.

Another poem, addressed to a bedridden young woman, begins with these lines:

> I come, my lady fair, from yon far-distant isle,
> Whose hills are ever green, whose soft skies ever smile.

It ends with these:

> Take me, lady, spurn me not; this blessing grant me,
> To mingle yet my life with thine, and e'en be one with thee.

Who was the fair lady who lived off the island and with whom Mitchell's poetic alter ego wished to merge her life?

Quite possibly, Ida Russell.

No record survives of how Maria and Ida first met, but the two women, born within months of each other and a world apart—Russell's father had served as the American ambassador to Sweden, where she was born in 1818—grew intensely close across the distance between Nantucket and Ida's

Massachusetts hometown, named for the author of *Paradise Lost.*

In her journals, Mitchell rarely reflected on her emotions, whether because she found them uninteresting or because the beam of her intellect was aimed so far beyond the human realm that she remained rather opaque to herself. Her feelings for Ida are a rare exception. In one of the very few emotionally introspective entries in her diary, Maria writes ruefully:

> Last night I had two letters which did me good. One was from Lizzie Earle and one from Ida Russell. The love of one's own sex is precious for it is neither provoked by vanity nor retained by flattery; it is genuine and sincere. I am grateful that I have had much of this in my life. I am sometimes sorry that those who give me so much, should give it to me when it might be so well suited to the domestic station of a wife and I am humbled when I consider that they give it to me because they know me so little—that, living in the same town with me, they would know me better and love me less. I have an entirely different regard for Lizzie and for Ida. I love Lizzie as one loves a sister, I admire Ida and am jealous of her regard for others. It is something like *love* and less generous than that which I have for Lizzie, which is affection . . .

Nobody knows what goes on between two hearts—including, more often than not, the people in whose chests they beat. But my own sense—based on years of immersion in Mitchell's world and in the complex universe of other same-sex relationships between her contemporaries, and on an awareness of how puritanical conceits constrict natural human sexuality—is that Ida may have been the love of Maria's life.

Ida Russell was bright and beautiful, socially active and endowed with a kind of magnetism that attracted uncommon ardor from men and women alike. She was listed among the audience members in the famous painting *Webster Replying to Senator Hayne* by George Healy—a depiction of the landmark

debate between the Massachusetts and South Carolina senators on preserving the Union on the eve of the Civil War. The artist worked on his remarkably detailed painting for seven years and populated the stately auditorium with 150 portraits of spectators. He placed the men on the floor and the women in the balcony, taking the creative liberty of filling the gallery with all the "loveliest ladies of the time," whether or not they had actually been present on the day of the debate. Ida Russell likely was not—she would have been a girl shy of twelve then—but her widely admired loveliness had induced Healy to paint her, as a young woman, into the final picture. The painting would come to be the largest piece of art in Boston's iconic Faneuil Hall. In March 2017, a bipartisan panel of five women—including the state's former governor, the first woman elected lieutenant governor in Massachusetts, and the first woman elected state treasurer and a gubernatorial nominee—would sit beneath it, reflecting on Hillary Clinton's defeat in the 2016 presidential election and issuing an old clarion call to a new generation of women leaders. One of the panelists, the former college president and lieutenant governor of Massachusetts Kerry Healey, would capture the mood of the moment: "Failure is the sinew that connects success." A century and a half earlier, Maria Mitchell had written in her diary:

> He who has never failed somewhere, that man can not be great. Failure is the true test of greatness.

Barely into her twenties, Ida Russell attended the groundbreaking salons hosted by Margaret Fuller—one of Mitchell's great intellectual heroes. In 1839, well before the publication of her paradigm-unmooring treatise *Woman in the Nineteenth Century,* twenty-nine-year-old Fuller launched a series of "Conversations for Women" in Boston. In a circular quoted by Emerson, Fuller framed the spirit of her project:

> Could a circle be assembled in earnest, desirous to answer the questions, "What were we born to do?" and "How shall we do it?" I should think the undertaking a noble one.

For five years, until she left Boston for New York, Fuller convened the area's most intellectually wakeful women to use Greek mythology and its inevitable astronomical dimensions as a springboard into conversations about beauty, truth, and life's grand questions.

Electrified by Fuller's "Conversations," Ida and her half sister Amelia applied to be among the few permanent residents at Brook Farm—a utopian community nine miles outside Boston, founded two years earlier upon the ideals of Transcendentalism by the former Unitarian minister George Ripley and his wife, Sophia. Part intellectual commune and part joint stock agricultural company, funded largely by tuitions to the school the Ripleys ran on the property, Brook Farm promised a gender-blind distribution of profits among its residents in proportion to their share of work on the farm—an arrangement intended to provide them with leisure for discussing ideas and cultivating the life of the mind. The novelist Nathaniel Hawthorne was one of the founding investors. Although Margaret Fuller never formally joined, she polished Brook Farm's image as an intellectual haven with her frequent visits. "At Brook Farm one man ploughed all day, & one looked out of the window all day & drew his picture, and both received the same wages," Emerson—whom the Ripleys tried to entice into joining—wrote in his journal. "I wished to be convinced, to be thawed, to be made nobly mad by the kindlings before my eyes of a new dawn of human piety." He was not.

By the time Ida and her sister joined in the autumn of 1842, Brook Farm had suffered an unhandsome collision between the ideal and the real. Its financial model had proven unviable, and the elated idealism that animated its founding ethos had

devolved into what Ida's sister would later describe as a life of "bare and cheerless routine." Hawthorne had just made a dramatic exit, demanding that his initial investment be refunded. "Even my Custom House experience," he roiled with indignation, "was not such a thraldom and weariness; my mind and heart were freer . . . Thank God, my soul is not utterly buried under a dung-heap."

Polarized by her own conflicting ideals, Ida Russell stood uneasy in the space between the possible and the permissible, shipwrecked by the tides of convention that delimit each era's horizon of possibility. At only twenty-one, she had invited Emerson to deliver one of his politically wakeful lectures in her hometown of Milton, but her name also appears as one of 24 nays on an antislavery resolution, against 250 yeas, including Frederick Douglass, William Garrison's wife, and Henry David Thoreau's mother and sister. While Ida commended Maria's scientific achievements as victories for her country and her sex, she beseeched Maria not to become a "platform woman"—a public advocate for the era's two great directions of social reform, African American and women's rights. In a diary entry from 1854, when both women were thirty-six and Ida had fallen ill, Mitchell relays an exchange that bespeaks her own good-natured idealism and sunny wit with an edge of storm:

> I went down to see Ida Russell ten days ago. I was curious to see for myself whether sickness had changed her in body and spirit. I found her much the same Ida . . . strong in her dislike of the "platform women" as she calls the Antislavery and woman's rights people. I told her not to speak of them with such contempt as I had always felt that when I was pushed for money I could write some astronomical lectures and go into the cities and deliver them. "Don't Maria," she said, "do anything else. Take a husband even!"
>
> (I) What! The weak minded man such as would happen to fall in love with me?
>
> (Ida) Well, then there's the river.

gleam of light"—a metaphor evocative of the kaleidoscopic water bowl that hung above the brass telescope in Mitchell's childhood home. Though consumed with grief, she steps beyond the lacerating news of Ida's death to record a sorrowful meditation on life:

> As our circle of friends narrows, they naturally seem to clasp us in a closer embrace. It is the sad mercy of growing old, that we outlive one and another of those we love.

For years, Mitchell had been dreaming of and saving for a trip to Europe—the homeland of her many long-gone heroes. Her greatest American idol had framed visiting Europe as nothing less than a moral imperative for intellectually and politically wakeful Americans. "What was but a picture to us becomes reality," Margaret Fuller had written from Rome months after Mitchell's comet discovery, "remote allusions and derivations trouble no more: we see the pattern of the stuff and understand the whole tapestry." In the year following Ida's death, Mitchell's European dream began taking shape as a reality from which she could no longer abstain. She turned in her resignation from the Atheneum after a two-decade tenure and began making arrangements, planning routes, dreaming up visits with the intellectual idols and kindred spirits she yearned to meet: Europe's leading astronomers, including the polymathic astronomer and Royal Astronomical Society cofounder Sir John Herschel—son of William and nephew of Caroline Herschel, who had introduced him to astronomy—as well as the poet Elizabeth Barrett Browning, the mathematician Mary Somerville, the naturalist Alexander von Humboldt, and the young expatriate American sculptor Harriet Hosmer, who was living in Rome and breaking ground for women in art as Mitchell was doing in science. "Figures are a common language," she would soon write while traveling through foreign

lands and listening to foreign tongues. Nearly a century later, at the apogee of the Second World War's violent divisiveness, Albert Einstein's soft, heavily accented voice would stream through London's airwaves to deliver a conciliatory speech titled "The Common Language of Science."

In July 1857, Mitchell boarded a steamship in New York. Having narrowly avoided a collision with another ship, it arrived in Liverpool ten days later—on her thirty-ninth birthday. She was soon introduced to the improbable American consul at Liverpool—Nathaniel Hawthorne. Four years earlier, the novelist had been awarded America's most lucrative foreign post by his college friend Franklin Pierce, newly elected the fourteenth president of the United States—a victory Pierce attributed to the highly idealized biography of him that Hawthorne had written during the campaign. The author was now living the high life in Liverpool with his wife, the unrealized artist Sophia Peabody, and their three children.

Sophia's elder sister Elizabeth—an education reformer, founder of the first English-language kindergarten in America, and translator of the first American edition of Buddhist scripture—had once extolled Hawthorne as "handsomer than Lord Byron." But Mitchell, unimpressed with the man said to have it all, recorded in her diary:

> He is not handsome, but looks as the author of his books should look: a little strange and odd, as if not of this earth. He has large, bluish-gray eyes; his hair stands out on each side, so much so that one's thoughts naturally turn to combs and hair-brushes and toilet ceremonies as one looks at him.

Perhaps Mitchell found the dour, incurious, perennially dissatisfied Hawthorne unhandsome because her ideas about beauty were rooted in a deeper stratum of truth, a wonderment at the nature of reality.

In the following century, the poet Edna St. Vincent Millay would enroll in Vassar. Immersed in the comprehensive science curriculum Mitchell had established, she would write in one of her early sonnets: “Euclid alone has looked on Beauty bare.”

Euclid, whose work Kepler part built upon and part refuted, fathered geometry and provided the first foothold of scientific certitude. In perfect Euclidean geometry, the angles inside a triangle always add up to 180 degrees—the very first mathematical proof, a validation of truth unmoored from human judgment and opinion. It was the lightning bolt that sundered the tree of knowledge into philosophy and pure science.

Euclid’s Elements remains one of the most influential scientific texts of all time, on a par with Newton’s *Principia.* For centuries after Euclid’s death, his geometry remained our only model of understanding space. This breakthrough in science shaped art through the development of perspective—a technique originally called *geometric figuring,* which invited architecture and the figurative arts into the three-dimensional world for the first time, then through them gave back to science. Galileo’s Moon drawings were so revolutionary in large part because, trained in perspective, he depicted the topography of its mountains and craters, emanating the radical suggestion that our satellite is not a perfectly smooth orb of ethereal matter but as solid and rugged as the earth—not a heavenly body but a material one. Mere months earlier, the English mathematician and astronomer Thomas Harriot had become the first person known to make a drawing of the Moon seen through a telescope. Untrained in perspective and ignorant of the Euclid-informed projective geometries that had made their way to Florence but not yet to England, he depicted the Moon as a dappled disc resembling an engraved medal. The genius that led Galileo to see what Harriot could not was indelibly *genius loci,* as much a function of his mind as of his time and place.

Still, Euclid's geometry of space seemed at first too unreal, too intangible—an abstraction, an illusionist trick. It wasn't until Galileo and Descartes—whose visionary Cartesian plane married geometric shape and algebraic equation—upheld it as the mathematical poetics of the real world that it gained traction as truth incarnate. It was reality bare, and it was beautiful.

The question of beauty's purpose and significance had arisen as one of the animating inquiries at Margaret Fuller's "Conversations," when during an 1841 session devoted to Minerva, the Roman goddess of wisdom, many of the women insisted that "the principle of Beauty" ought to be factored into any definition of wisdom. Fuller then ruled that a definition of beauty must be devised first. She asked each woman in attendance to provide her own. One defined it as "the Infinite apprehended." Another argued that beauty is "the central unifying power" of existence. Brook Farm cofounder Sophia Ripley pointed to it as an embodiment of "the All" and defined it as "the mode in which truth appears." But Fuller, in her role as sybil-arbiter, observed that these definitions could be applied equally to love and truth. Challenging the women to reflect further, she tasked them with composing short essays of more precise definition for the next gathering.

That year, Emerson wrote in his journal:

> The presence or absence of Milton will very sensibly affect the result of human history. . . . Tomorrow, a new man may be born, not indebted like Milton to the Old, & more entirely dedicated than he to the New, yet clothed like him with beauty.

The debate about beauty impressed itself upon the mind of the young Sophia Peabody, who was in awed attendance at Fuller's gathering. Seventeen years later, while traveling through Europe with Maria Mitchell, Sophia—by then Sophia

Hawthorne—would gaze up at the fan vaulting over Queen Catharine's tomb and reflect:

> Take one of the divisions by itself and it looks like a rocket falling in stars or flowers, the motion in rest everywhere suggested. In comparing Gothic with the Greek architecture, one is the clear, logical understanding, coming at truth mathematically by the way of reason; and all this range of truth stands beautiful and sure, on lovely, even pillars, surmounted with square pediments, symmetrical and perfect to the eye.

Contrasting this with the Gothic, which traffics in "baffling geometric conclusions, setting known, established rules at defiance, wild beyond reach of recognized art, flaming like fire, glowing like flowers and rainbows, soaring like birds, struggling for freedom, and like the soul, never satisfied," she concludes:

> A cathedral is really an image of the whole soul of man; and a Greek temple, of his understanding only—of just decisions, serene, finished postulates, settled axioms. We need both.

Standing beneath the Euclidean dome, Sophia is renouncing the forced, limiting polarity of truth versus beauty, calling instead for a union—truth *and* beauty, the purifying clarity of mathematics married with the swirling wildness of contemplation that belongs to philosophy and art.

As her ever-gloomy husband sits out the Sistine Chapel and bemoans "this cold, rainy, filthy, stinking, rotten, rascally city"—"I hate it worse than any other place in the whole world," Nathaniel Hawthorne repines in his journal—Sophia visits the Tribune of Galileo at the Museum of Natural History—"a sort of temple erected to Galileo by the present Grand Duke Leopold —Galileo's heart being long ago thoroughly broken." In her journal, she reflects on how truth confers beauty—and how it

Russell at one of Fuller's "Conversations," convened in Elizabeth Peabody's book-shop. In addition to possessing the intellectual curiosity requisite for attending Fuller's salons, Ida Russell was almost unbearably beautiful. The relationship that blossomed between the two women was so intimate that Hawthorne soon fumed with jealousy. In a letter from the autumn of 1841, he beseeches Sophia to fall into his arms instead of Ida's:

> Dearest, I write of nothing; for I had nothing to write when I began, save to make thee aware that I loved thee infinitely; and now that thou knowest it, there is no need of saying a word more. On Monday evening, please God, I shall see thee. How would I have borne it, if thy visit to Ida Russel [*sic*] were to commence before my return to thine arms?

Sophia did eventually choose Nathaniel over Ida—they were married the following July and rode off into the sunset in a downpour, besieged by what she described in her diary as the "celestial artillery" of low thunder.

Not long after, Hawthorne himself would be magnetized into a friendship of similar romantic intensity. On August 5, 1850, he met Herman Melville at a literary gathering in the Berkshires. Hawthorne was forty-six and Melville, born on Maria Mitchell's first birthday, had just turned thirty-one. A potent intellectual infatuation ignited between the two men—one that, at least for Melville, seems to have grown from the cerebral to the corporeal. Within days, the young author reviewed Hawthorne's short story collection *Mosses from an Old Manse in Literary World* under the impersonal byline "a Virginian Spending July in Vermont." No claim of this intentional ambiguity was true—Melville was a New Yorker, the month was August, and he was spending it in Massachusetts.

The review, nearing seven thousand words, was nothing less than an editorial serenade. "A man of a deep and noble nature

has seized me in this seclusion. . . . His wild, witch voice rings through me," Melville wrote of reading Hawthorne's stories in a remote farmhouse nestled in the summer foliage of the New England countryside. "The soft ravishments of the man spun me round in a web of dreams." Melville couldn't have known that his allusions to witchcraft, intended as compliment, had disquieting connotations for Hawthorne. Born Nathaniel Hathorne, he had added a *w* to the family name in order to distance himself from his ancestor John Hathorne—a leading judge involved in the Salem witch trials, who, unlike the other culpable judges, never repented of his role in the murders. Unwitting of the dark family history, Melville found himself under "this Hawthorne's spell"—a spell cast first by his writing, then by the constellation of personal qualities from which the writing radiated. Who hasn't fallen in love with an author in the pages of a beautiful book? And if that author, when befriended in the real world, proves to be endowed with the splendor of personhood that the writing intimates, who could resist falling in love with the whole person? Melville presaged as much:

> No man can read a fine author, and relish him to his very bones, while he reads, without subsequently fancying to himself some ideal image of the man and his mind. . . . There is no man in whom humor and love are developed in that high form called genius; no such man can exist without also possessing, as the indispensable complement of these, a great, deep intellect, which drops down into the universe like a plummet. Or, love and humor are only the eyes, through which such an intellect views this world. The great beauty in such a mind is but the product of its strength.

After comparing Hawthorne to Shakespeare, he writes:

> In this world of lies, Truth is forced to fly like a scared white doe in the woodlands; and only by cunning glimpses will she reveal herself, as in Shakespeare and other masters of the

> great Art of Telling the Truth,—even though it be covertly, and by snatches.

Could it be that the young Emily Dickinson, then nineteen and a voracious reader, absorbed Melville's sentiment and later transmuted it into her iconic line "Tell all the truth but tell it slant"? But while creative work arises from the combinatorial process of transfiguring existing fragments of thought and image into new combinations, Melville himself admonished in this very piece, "Mark it well, imitation is often the first charge brought against real originality."

"I am Posterity speaking by proxy," Melville bellows from the page, "when I declare—that the American, who up to the present day, has evinced, in Literature, the largest brain with the largest heart, that man is Nathaniel Hawthorne." In an aside on the process of composing his review, he notes that twenty-four hours into writing, he found himself "charged more and more with love and admiration of Hawthorne." Quoting an especially beguiling line of Hawthorne's, he insists that "such touches . . . can not proceed from any common heart." No, they bespeak "such a depth of tenderness, such a boundless sympathy with all forms of being, such an omnipresent love" that they render their author singular in his generation—as singular as the place he would come to occupy in Melville's heart.

Fervid correspondence and frequent visits followed over the next few months. Only ten of Melville's letters to Hawthorne survive, but their houses were just six miles apart and they saw each other quite often—"discussing the Universe with a bottle of brandy & cigars," as Melville put it in one invitation, and talking deep into the night about "time and eternity, things of this world and of the next, and books, and publishers, and all possible and impossible matters," as Hawthorne recounted in his diary. Punctuating the invisible log of all that was written but