

BOOK CLUB SYNOPSIS

Leonardo da Vinci

Walter Isaacson

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Leonardo da Vinci

Fifteenth century Florence was not only a flourishing cultural and artistic hub, full of scholars, artisans, merchants and bankers, it was also undeniably a place of financial and ideological abundance. In this remarkable city that paved the way for the early Renaissance in Europe, one of history's greatest visionaries—Leonardo da Vinci—rose to prominence. As the artist behind two of the world's most famous paintings, the Mona Lisa and The Last Supper, da Vinci is lesser known as a man whose wide-ranging interests in science and technology inspired a number of inventions and discoveries. Even still, his enthusiasm for cross-disciplinary studies, ranging from creating weaponry for deployment in the military to uncovering the mathematics of optics, ranks da Vinci among the world's most renowned creative geniuses, and his passion for learning serves as the ultimate recipe for inspiration and ingenuity. In *Leonardo da Vinci*, Walter Isaacson explores the life and legacy of the man behind the masterpieces and arms readers with practical takeaways about the power of creativity, inspiring us all to think a little differently.

ABOUT THE AUTHOR

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CHAPTER ONE

CHILDHOOD (VINCI, 1452–1464)

DA VINCI

Going back five generations, the legitimate sons of Leonardo da Vinci's family were notaries, a prominent role given the rise of Italy's mercantile economy. In the 1300s, his great-great-great-grandfather Michele had been a notary in Vinci, 17 miles west of Florence.

But Leonardo was not a legitimate son of his line. His father Piero, on a visit to Vinci, had a "relationship with an unmarried local peasant girl, and in the spring of 1452 they had a son." Leonardo's grandfather Antonio "recorded the birth on the bottom of the last page of a notebook that had belonged to his own grandfather." Excluded from the record was the name of Leonardo's mother, whose identity as Caterina Lippi, a 16-year-old girl born in 1436 and orphaned at 14 years old, could be gleaned from a later tax document.

Belonging to different social classes, Caterina and Piero would not have and did not wed. Piero would, in fact, later marry 16-year-old Albiera, the daughter of a prominent Florentine shoemaker, eight months after Leonardo was born. But Piero did set up Caterina with a local farmer and kiln worker named Antonio di Piero del Vaccha, also known as "Accattabriga," the "Troublemaker," who had ties to the da Vinci family. Instead of in the da Vinci house, where a newborn illegitimate son would have caused Piero trouble in negotiating a dowry with his fiancée's family, many place the birth of Leonardo in a gray stone cottage next to a farmhouse two miles from Vinci.

The land was owned by the family of Piero di Malvolto, godfather to both Piero da Vinci and Leonardo, “which would have made sense if Leonardo had been born on his property.” Piero di Malvoto’s 70-year-old mother lived on the property, and her “dilapidated cottage ... may have been the ideal safe place to shelter Caterina while she was pregnant.”

Despite these circumstances, Leonardo was baptized before a large and prominent crowd the day after he was born. A week later, his father returned to Florence, after which time Leonardo split his childhood between two homes: that of Caterina and Accattabriga, who “settled on a small farm on the outskirts of Vinci,” and that of his grandfather Antonio da Vinci. But by the time Leonardo was five years old, he was “primarily living in the da Vinci family home with his leisure-loving grandfather Antonio and his wife.” Also in the house was his uncle Francesco, who was only 14 years his senior and who “became Leonardo’s beloved uncle and at times surrogate father.”

“A GOLDEN AGE FOR BASTARDS”

“As Leonardo’s well-attended baptism attests, being born out of wedlock was not a cause for public shame. The nineteenth-century cultural historian Jacob Burckhardt went so far as to label Renaissance Italy ‘a golden age for bastards,’” which proved particularly true among the ruling aristocracy. Among the middle classes, however, illegitimate children were more frequently culturally ostracized, and being born out of wedlock “created an ambiguity of status,” as Leonardo would learn when it came time to collect on his family inheritance.

That said, “[illegitimacy] freed some imaginative and free-spirited young men to be creative at a time when creativity was increasingly rewarded.” Because he was barred from being a notary on account of his birth, “Leonardo was able to benefit from the note-taking instincts that were ingrained in his family heritage while being free to pursue his own creative passions.”

DISCIPLE OF EXPERIENCE

Leonardo's illegitimacy also prevented him from attending the usual "Latin schools" that taught the classics and humanities to well-groomed aspiring professionals and merchants of the early Renaissance." He learned basic math at a so-called "abacus school" but otherwise was forced to teach himself and learn through his own experimental approaches. "This freethinking attitude saved him from being an acolyte of traditional thinking," ultimately leading him to develop an empirical approach to knowledge. To that was added an almost superhuman ability to "perceive shapes and shadows with wondrous precision," with particular attention to the complexities of movement. With the printing press just starting to churn out books en masse, peace burgeoning in Italy and scholars from Turkey fleeing to Europe, "[it] was a good time for a child with such ambitions and talents to be born."

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CHAPTER TWO

APPRENTICE

THE MOVE

In 1464, Leonardo's stepmother Albiera and grandfather Antonio died. This prompted a move from Vinci to Florence, where his father Piero had been living. Although Leonardo rarely wrote explicitly about his feelings, his personal writings do reveal a fondness for the countryside and a general disdain for urban living. "‘Leave your family and friends and go over the mountains and valleys into the country,’ he instructed aspiring painters. ‘While you are alone you are entirely your own master.’" Yet he would spend most of his life in cities, thriving.

Piero equipped his son with a "rudimentary education and would soon help him get a good apprenticeship and commissions." Yet he never went through the process of granting Leonardo legitimacy. Walter Isaacson speculates that Piero may have wanted to wait until he had an heir that was born legitimately. It is also possible that he did not see a purpose in going through the process given the notary guild's rule against admitting sons born out of wedlock even if they were legitimized.

FLORENCE

In the 1300s, Florence had become a republic, and elected delegates met at the Palazzo della Signoria, which is now known as the Palazzo Vecchio. "The republic was not, however, democratic or egalitarian." Behind the scenes, the powerful Medici family ruled, using its power over the banking industry to exercise control.

In the 1430s, when Cosimo de' Medici took over, the family bank became the largest in Europe, and Cosimo became the de facto ruler of Florence. With a great interest in ancient Roman and Greek antiquities, he created the Platonic Academy, "where scholars and public intellectuals discussed the classics." When Leonardo arrived in Florence, Cosimo's grandson Lorenzo had taken over. During his reign, Lorenzo sponsored Sandro Botticelli and Michelangelo Buonarroti, helping to create a city culture that "rewarded, above all, those who mastered and mixed different disciplines."

In fact, the city's artisans and creative intelligentsia were known for their multidisciplinary achievements. And the "mixing of ideas from different disciplines became the norm as people of diverse talents intermingled," leading to the creation of everything from Florence's cathedral, crowned with the world's largest dome, to new fashions, architectural styles and artistic developments.

Among the city's population of 40,000, "[there] were at least a hundred families that could be considered very wealthy, plus some five thousand guild members, shopkeepers, and merchants who were part of a prosperous middle class," many of whom asserted their status through conspicuous consumption and patronage of the arts. A third of its population was literate, the highest rate in Europe at the time.

With a flourishing economy and no shortage of skilled artisans, the city interwove art, technology and commerce. "There was no place then, and few places ever, that offered a more stimulating environment for creativity than Florence in the 1400s."

BRUNELLESCHI AND ALBERTI

The designer of the cathedral dome, Filippo Brunelleschi (1377–1446), had an undeniable impact on Leonardo. The son of a notary, Brunelleschi trained in goldsmithing, as a part of a guild that included silk weavers, merchants and sculptors. After deciding to pursue architecture, he traveled to Rome with his friend Donatello to study classical ruins, measuring the Pantheon's dome and reading Vitruvius' *De architectura*. "To build his cathedral dome—a self-supporting structure of close to four million bricks that is still the largest

masonry dome in the world—Brunelleschi had to develop sophisticated mathematical modeling techniques and invent an array of hoists and other engineering tools.”

He also conducted painting experiments that revived and “advanced the classical concepts of visual perspective, which had been missing in the art of the Middle Ages.” Brunelleschi’s “formulation of linear perspective transformed art and also influenced the science of optics, the craft of architecture, and the uses of Euclidean geometry”—and greatly foreshadowed the work of Leonardo.

Leon Battista Alberti (1404–1472) would build on Brunelleschi’s theories of linear perspective. Also illegitimate, Alberti was granted a special dispensation, and he studied law at Bologna, was ordained a priest and wrote for the pope. “During his early thirties, Alberti wrote his masterpiece analyzing painting and perspective, *On Painting*, the Italian edition of which was dedicated to Brunelleschi.” Alberti was particularly passionate about advancing the public intellectual discourse, and he would share his work openly. “*On Painting* expanded on Brunelleschi’s analysis of perspective by using geometry to calculate how perspective lines from distant objects should be captured on a two-dimensional pane. ... By applying mathematics to art, Alberti elevated the painter’s status and advanced the argument that the visual arts deserve a standing equal to that of other humanist endeavors, a cause that Leonardo would later champion.”

EDUCATION

At abacus school, the only formal education Leonardo would complete, he learned how to do practical mathematics. In the process, he became skilled at using analogies to understand similarities between different cases. “Analogies and spotting patterns became for him a rudimentary method of theorizing.” He was good at geometry but never mastered algebra or Latin, the latter of which he would continue to attempt to learn even into his late thirties. He was left-handed and would write backward across the page so as not to smudge the wet ink; in his art, he would draw from right to left as well. “[It] was one more way in which Leonardo was regarded, and regarded himself, as distinctive.”

VERROCCHIO

When Leonardo was 14, his father secured him an apprenticeship with Andrea del Verrocchio, “a versatile artist and engineer who ran one of the best workshops in Florence.” There, “Verrocchio conducted a rigorous teaching program that involved studying surface anatomy, mechanics, drawing techniques, and the effects of light and shade on material such as draperies.” Projects when Leonardo arrived included an ornate tomb for the Medici, a bronze statue of Christ and Saint Thomas, and Madonna paintings for merchants. On the main floor of the workshop was an open workroom, with many apprentices and workers living on the floor above. “The goal was to produce a constant flow of marketable art and artifacts rather than nurture creative geniuses yearning to find outlets for their originality.”

Leonardo may even have modeled for one of Verrocchio’s bronze statues of *David*, but his art was “sometimes criticized as workmanlike” and stylistically “hard and crude.” Yet the detailed curls and masterful anatomical accuracy depicted in Verrocchio’s *David* would become hallmarks of Leonardo’s work, even as he surpassed his teacher.

Leonardo also learned the beauty of geometry from Verrocchio. “After Cosimo de’ Medici died, Verrocchio designed a marble-and-bronze slab for his tomb.” On it was a geometrical pattern featuring “carefully proportioned rectangles and half-circles in colors that were based on harmonic ratios and the Pythagorean musical scale. There was harmony in proportions, Leonardo learned, and math was nature’s brushstroke.” Two years later, when Leonardo was 19, the workshop would be tasked with mounting a two-ton ball on top of Brunelleschi’s dome, which required the copper on the ball to be soldered using mirrors that focused the heat of the sun. Once completed, the project was met with much praise and inspired in Leonardo a lifelong fascination with optics and mirrors.

A rival to Verrocchio, Antonio del Pollaiuolo, at the time was performing surface dissections of humans to study anatomy and further explore the art of human movement. This work would also have a lasting impact on Leonardo.

DRAPERIES, CHIAROSCURO, AND SFUMATO

At Verrocchio's studio, Leonardo conducted many studies involving draperies, depicting how light and shadow played about in the folds. These "helped foster one of the key components of his artistic genius: the ability to deploy light and shade in ways that would better produce the illusion of three-dimensional volume on a two-dimensional surface." In Leonardo's own words: "The first intention of the painter ... is to make a flat surface display a body as if modeled and separated from this plane, and he who surpasses others in this skill deserves most praise. This accomplishment, with which the science of painting is crowned, arises from light and shade," a technique artists refer to as *chiaroscuro*.

At this time, Leonardo also pioneered *sfumato*: "the technique of blurring contours and edges" as a means for painters to "render objects as they appear to our eye." The term comes from the Latin word for "smoke," and was a defining trait of Leonardo's work. In a series of maxims for artists, he once wrote, "Your shadows and lights should be blended without lines or borders in the manner of smoke losing itself in the air."

WARRIORS WITH HELMETS

In 1471, Verrocchio's studio was involved in the Medici family's preparations for an important visit from Galeazzo Maria Sforza, Duke of Milan. They were tasked with redecorating the Medici guest quarters and crafting a suit of armor and ornate helmet as a gift. Perhaps inspired by this visit, Leonardo's most famous early drawing came from this time. The piece depicts a near-caricature of a gruff old warrior in profile, wearing an ornate chest piece and helmet, and the man's "hooked nose and jutting jaw" would later become "a leitmotif in Leonardo's drawings."

PAGEANTS AND PLAYS

Leonardo also seemed to take joy in designing for the stage. Whether through costumes, stage machinery, set pieces or special effects, the theater allowed him to exercise his mastery of perspective. "He studied how to make the rules of perspective work for different vantage points"

and “loved mixing illusion with reality.” Isaacson believes that some of the more fantastical and impractical drawings and inventions in Leonardo’s notebooks can be attributed to his love for theater entertainment—not inventions meant to be real. Among these, Isaacson names the famous “aerial screw” helicopter.

THE ARNO LANDSCAPE

In 1472, Leonardo’s formal apprenticeship came to an end, but he stayed on at Verrocchio’s studio, joining the Florentine painters’ confraternity, the Compagnia di San Luca, which was “not a guild but a club-like mutual aid society or fraternity.” Although it had existed for a century, “it was undergoing a revitalization partly because artists were reacting against Florence’s antiquated guild system,” which grouped artists with physicians and pharmacists. “By the late 1400s [the Compagnia] were eager to assert a more distinctive status for themselves.”

In the summer of 1473, Leonardo took a trip back to Vinci, where he made what may be his earliest surviving drawing: a panorama of the hills around the Arno River. “There are a few familiar landmarks from the area—a conical hill, perhaps a castle—but the aerial view seems to be, typical of Leonardo, a mix of the actual and the imagined, viewed as if by a soaring bird. The glory of being an artist, he realized, was that reality should inform but not constrain.” Leonardo later wrote, “If the painter wishes to see beauties that would enrapture him, he is master of their production.”

TOBIAS AND THE ANGEL

In Verrocchio’s painting depicting the story of Tobias and his guardian angel, Leonardo was responsible for painting the dog and the fish. When comparing Verrocchio’s painting of the biblical tale to Antonio Pollaiuolo’s (a contemporary and rival), Leonardo’s masterful contributions become evident. Both paintings share the same elements, but Leonardo’s dog is noteworthy for its lively movement and the details of its curls, matching the curls above Tobias’ left ear, which Leonardo also painted. The fish has a drip of blood flowing from its body, alluding to the healing powers of its guts in the tale of Tobias, a

tiny but meaningful detail. Light bounces off of the gills, scales and eye of Leonardo's fish in a manner unparalleled by Pollaiuolo's efforts.

"In this deeply pleasing and sprightly painting, we can see the power of a master-pupil collaboration. Leonardo was already an extreme observer of nature, and he was mastering the ability to convey the effects of light on objects. Added to that, he had imbibed from Verrocchio, the master sculptor, the excitement of conveying motion and narrative."

BAPTISM OF CHRIST

In the mid-1470s, Verrocchio and Leonardo completed another important piece: *Baptism of Christ*, which depicts "John the Baptist pouring water over Jesus while two angels kneeling beside the River Jordan watch." Leonardo was responsible for the angel on the left—most side of the painting and Leonardo's biographer Giorgio Vasari claimed that the mastery Leonardo displayed when painting the angel made Verrocchio give up art. While this is plainly hyperbolic, Isaacson points out that Verrocchio indeed never made another solo painting. *Baptism of Christ* is remarkable for its heavy use of oil paints, with multiple thin layers, one on top of the other, that were then smoothed by fingertips—a technique Leonardo was known for. Verrocchio at this point was still using tempera: a mixture of water-soluble pigments and egg yolk.

"The most striking trait of Leonardo's angel is the dynamism of his pose. Shown from slightly behind in a twisted three-quarter profile, his neck turns to the right as his torso twists slightly to the left." Comparing his angel to that painted by Verrocchio in his *Christ and Saint Thomas* reveals the ways in which the student, Leonardo, had surpassed his teacher. Most notably, Leonardo's angel has softer features, with his curls blending into the smooth contours of his highly expressive face—in part due to the new medium of oil paint—while Verrocchio's tempera angel looks almost wooden in its expression. Leonardo's smooth versus Verrocchio's sharp lines can also be seen in Jesus' legs as compared to John the Baptist's.

When painting the background and foreground, Leonardo once again employed the *sfumato* technique, the flowing water demonstrating his fascination with naturally occurring spirals.

THE ANNUNCIATION

The Annunciation is one of four paintings Leonardo did primarily on his own during his twenties. It depicts the moment the angel Gabriel told Mary that she would conceive the Messiah. Though it remains important in tracing the career of Leonardo, it is nonetheless an awkward work. The wall encircling the garden in the scene is painted at a different angle than the rest of the painting, and its opening has a sharp angle out of step with the other perspectives. Mary's dress is painted with a rigidity that undermines the flow of the cloth but mirrors her expressionless face. The trees in the background are painted the same size despite the fact that one seems like it should be closer to the viewer and therefore larger. But "[the] most discomforting lapse involves the awkward positioning of Mary in relation to the ornate lectern. ... The lectern's base is a few feet closer to the viewer than Mary is, which makes it seem that she is too far away for her right arm to reach the book, yet her arm extends across it, appearing oddly elongated." Fortunately, a number of the inconsistencies in perspective can be explained by Leonardo's experimentation with anamorphosis, where a certain viewing angle is needed for the painting to appear right.

Despite the lack of a firm grasp on perspective in the painting, Gabriel's androgynous beauty, which Leonardo became known for, is as impressive as ever, as is the expressive motion of the angel's pose. Leonardo's growing skill with oil paint allowed him to create masterful shadows and light, depicting the sun's glow from the top left of the painting.

MADONNAS

Around the same time that he was capturing the Annunciation, Leonardo also completed two paintings of the Madonna with baby Jesus: *Madonna of the Carnation* and *Madonna and Child with Flowers*. They are notable for the anatomical accuracy and the use of chiaroscuro in depicting the fat infant Jesus. Both paintings allude to the crucifixion, even in the tender scene of a mother with her young baby. One has carnations, which were said to have sprung up from the tears of Mary on the day of Jesus' crucifixion, while a cross-shaped flower anchors the other. It is believed that the models for these paintings were Leonardo's father's children with his third wife.

GINEVRA DE' BENCI

Ginevra de' Benci, Leonardo's first nonreligious painting, "is the portrait of a melancholy young woman with a moonlike face glowing against the backdrop of a spiky juniper tree." With her tightly curled hair and an unconventional three-quarters pose, this portrait can be seen as a sort of precursor to the *Mona Lisa*. In this painting, Leonardo also returned to the motif of water, depicting a flowing river as a prominent focus, as in *Baptism of Christ*. Leonardo may have secured this commission through his father, who had ties to the Benci family. Another possible explanation is that it was commissioned by Bernardo Bembo, Venice's ambassador to Florence, who "struck up a proudly public Platonic relationship with Ginevra that made up in effusive adoration what it likely lacked in sexual consummation."

Leonardo's fingerprints can be seen in this piece, further proof of his experimentation with using his fingers to blend the thin layers of oil paint. The subject's eyes seem to be focusing on different things depending on which one you look at. "Also noticeable when staring at her eyes is the shiny liquid quality that Leonardo was able to achieve with his oils." Just to the right of each pupil and in her curls is a "perfect glint of luster—the white sparkle caused by a light hitting a smooth and shiny surface," which was "another of Leonardo's signature marks." He used such small details to impart a kind of emotional depth that is not evident at first glance. "In painting her, Leonardo created a psychological portrait, one that renders hidden emotions. That would become one of his most important artistic innovations."

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CHAPTER THREE

ON HIS OWN

L'AMORE MASCUINO

In April 1476, Leonardo, along with three others, was anonymously accused of having sex with a man. Nothing came of it, as no witnesses ever came forward. A few weeks later, he was again accused, but once again the charges were dismissed. According to Isaacson, “Leonardo was romantically and sexually attracted to men and, unlike Michelangelo, seemed to be just fine with that. He made no effort either to hide or proclaim it, but it probably contributed to his sense of being unconventional, someone who wasn’t geared to be part of a family procession of notaries.” Over the years, he would have a series of male companions, including Atalante Migliorotti, who would become a well-known musician, and a man nicknamed Salai, “the Little Devil.”

Homosexuality was not uncommon at the time, especially in the artistic circles of Florence. “When Leonardo worked for Verrocchio, a cult of Plato was arising among some Renaissance humanists, and it included an idealized view of erotic love for beautiful boys.” Yet sodomy was illegal, and the Officers of the Night—a special force tasked with investigating acts of immorality—regularly rounded up and punished those found guilty of it. In his writings, Leonardo did not seem particularly bothered by the nature of his sexual desires. His art far more often depicted male than female anatomy, and the female subjects of his art were always clothed—with perhaps only two exceptions. Yet he is still known for his moving and insightful paintings of women, and “his portraits of women are deeply sympathetic and psychologically insightful.”

ADORATION OF THE MAGI

In 1477, Leonardo left Verrocchio's bottega and opened his own workshop. "Commercially, it was a failure," and he was only known to have received three commissions in five years, two of which were left unfinished. The other commission was for an altar painting in the chapel of the Palazzo della Signoria, which was never started. That said, sketches suggest it would have shown the shepherds who came to see the newborn baby Jesus in Jerusalem, and the sketches were later repurposed in the most famous of Leonardo's incomplete works: *Adoration of the Magi*.

Commissioned by the monastery of San Donato, just outside of Florence, in March 1481, the elaborate contract was meant to force Leonardo to complete the work, with no obligatory payment if he took longer than 30 months, among other stipulations—including the demand that he pay for all of his own supplies. The scene he was to depict was a common one, and Botticelli's version in a nearby church certainly would have inspired Leonardo. "But then he set out to make one that, unlike Botticelli's, was filled with energy, emotion, agitation, and messiness. His concept ... was to produce a vortex—that spiral form he loved—centered on the infant Jesus, with a frenzied procession of at least sixty people and animals swirling around and engulfing him."

Extant sketches demonstrate the meticulousness with which Leonardo planned out the painting, using rulers and mathematically precise guiding lines. His assistants assembled an eight-foot square made of ten planks of poplar wood, upon which he sketched his underdrawing in chalk. Atop the chalk, he used a thin brush and ink, filling in shadows with a light blue wash. "This was a departure from the brown wash he and other painters traditionally used. Through his study of optics, he knew that a dusty and misty atmosphere gave a blue tint to shadows." Finally, he layered a white primer and began to paint, creating a swirl of characters and animals, all expressing distinct and powerful emotions and psychological states.

ABANDONED

"Leonardo went on to paint the sky in the *Adoration of the Magi* and some highlights of the human figures and parts of the architectural

ruins. Then he stopped.” Both Vasari and Giovanni Paolo Lomazzo, Leonardo’s early biographers, believe he probably felt overwhelmed by the enormity of the task he had planned—especially considering the he was a perfectionist. He reduced the number of figures from 60 to 30 or so, but this still presented a significant challenge, compounded by his obsession with light and shadow and the complex play of angles, perspective and the human eye.

“There was another reason, one even more fundamental, that Leonardo did not complete the painting: he preferred the conception to the execution,” claims Isaacson. In an apparent self-portrait on the right side of the painting, Leonardo seems to have demonstrated his disinterest, depicting a young man drawn in toward the young Jesus but with his head sharply turned away, as if distracted by something else.

After seven months, payments stopped, and so did Leonardo. The painting was instead taken up by Botticelli’s protégé Filippino Lippi, and Leonardo departed to Milan.

SAINT JEROME IN THE WILDERNESS

Around this time, Leonardo began *Saint Jerome in the Wilderness*, which was based on the character of Jerome, “a fourth-century scholar who translated the Bible into Latin, during his retreat as a hermit in the desert.” In the painting, Jerome is shown in a state of deep emotion, and the “saint’s entire body, through its twists and uncomfortable kneeling, conveys passion,” with a rock in his outstretched hand ready to beat his chest in penance and an anguished grimace on his face. Also notable are the fine anatomical details. One such detail in the neck suggests that Leonardo began this painting in the 1480s and then came back to it after 1510, when he had gleaned more anatomical knowledge. This “shows that Leonardo’s record of unreliability was not simply because he decided to give up on certain paintings.” Rather, “he wanted to perfect them, so he kept hold of many of them for years, making refinements.”

MOTIONS OF THE MIND

“Leonardo was pioneering a new style that treated narrative paintings and even portraits as psychological expositions.” In doing so, he “sought to portray not only *moti corporali*, the motions of the body, but also how they related to what he called ‘atti e moti mentali,’ the attitudes and motions of the mind. More important, he was a master at connecting the two.” Alberti, in *On Painting*, said, “Movements of the soul are made known by movements of the body.” Leonardo echoed this sentiment in his own writings, and the connection between mind and body guided his anatomical dissections, as he aimed to discover which nerves corresponded to which muscles.

DESPAIR

Perhaps discouraged by his failure to complete the *Adoration of the Magi* and *Saint Jerome*, Leonardo seems to have fallen into something like depression. His journals from this time show a melancholic streak. “We do not lack devices for measuring these miserable days of ours, in which it should be our pleasure that they be not frittered away without leaving behind any memory of ourselves in the mind of men,” he wrote on one page. On another: “While I thought that I was learning how to live, I have been learning how to die.” Compounding his feeling of failure was the success of his rivals, particularly Botticelli, who had become a favorite of the Medici. “As he approached his thirtieth birthday, Leonardo had established his genius but had remarkably little to show for it publicly.” It was time for a change.

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CHAPTER FOUR

MILAN

CULTURAL DIPLOMAT

“In 1482, the year he turned thirty, Leonardo da Vinci left Florence for Milan, where he would end up spending the next seventeen years.” He was traveling with Atalante Migliorotti, then 15 years old, and a lyre made partly of silver in the shape of a horse’s skull, which—in addition to Leonardo’s services—was to be a gift to the Duke of Milan Ludovico Sforza, who had a great appreciation for the arts. This was all “probably part of a February 1482 diplomatic delegation headed by Bernardo Rucellai, a wealthy banker, arts patron, and philosophy enthusiast who was married to Lorenzo’s older sister and had just been made Florence’s ambassador to Milan.”

Milan’s population of 125,000 made it three times the size of Florence, but unlike Florence, Milan lacked a significant number of master artists, though it was well-stocked with scholars and intellectuals from a variety of other fields. “In other words, Milan’s castle provided a perfect environment for Leonardo, who had a fondness for strong leaders, loved the diversity of talent they attracted, and aspired to be on a comfortable retainer.”

THE JOB APPLICATION

Shortly after arriving in Milan, Leonardo wrote a letter to Sforza highlighting the specific services he could provide, including several ways to wage an offensive or defensive war. He offered practical

demonstrations for all his claims should they be met with skepticism, but notably, he made no mention of his artistic or creative skills. “Partly this was to appeal to Ludovico, whose Sforza dynasty had taken power by force and was faced with the constant threat of a local revolt or French invasion.” Another possible reason was that Leonardo, at the time, felt stymied in his artistic endeavors.

MILITARY ENGINEER

Even while still in Florence, Leonardo had begun sketching potential military inventions. These included a machine that knocked over ladders placed against a castle wall by would-be raiders, a propeller-like blade that would kill any who made it to the top of the wall and a rolling siege machine that could place a covered bridge down at the top of a castle wall. Many of his ideas were built upon the works of 13th-century scientist Roger Bacon and Roberto Valturio’s *On the Military Arts*, the Latin version of which Leonardo attempted to read to improve his understanding of the language. One of Valturio’s drawings was of a chariot with a scythe attached to each wheel, but Leonardo would take this idea and add many more swirling blades in one of his own drawings.

In the process of trying to discover how much more force a large crossbow could generate over a normal-sized one, Leonardo devised a giant crossbow 80 feet across. His calculations were off, but he demonstrated a natural understanding for the ways in which force would increase or decrease based on mechanical variables. “As with the scythed chariot, a question arises: How serious was Leonardo? Isaacson believes Leonardo was serious but that such things should fall into the category of imagination rather than invention—and the crossbow was one of many things Leonardo conceived of but never actually pursued. Of his many military inventions, only one made it into production: the wheel lock, a mechanism for igniting a gun.

THE IDEAL CITY

Without commissions in his early years in Milan, Leonardo spent a lot of time sketching. He turned to designing an “ideal city,” in part inspired by the very recent spread of the bubonic plague. His “idea was to combine the streets and canals into a unified circulation system.

The utopian city he envisioned would have two levels: an upper level designed for beauty and pedestrian life, and a level hidden below for canals, commerce, sanitation, and sewage.” Although Leonardo’s designs were never implemented, Isaacson suggests that they “might have transformed the nature of cities, reduced the onslaught of plagues, and changed history.”

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CHAPTER FIVE

LEONARDO'S NOTEBOOKS

THE COLLECTIONS

Starting in the early 1480s, Leonardo “began his lifelong practice of keeping notebooks on a regular basis.” He kept one such notebook on his belt “to record interesting scenes, especially those involving people and emotions.” Wherever he went, he would jot down things he might want to draw inspiration from later, mechanical sketchings or just notes to himself. More than 7,200 pages have survived to the modern day, comprising only about one-quarter of his total.

“Early on, Leonardo primarily recorded ideas that he considered useful to his art and engineering.” For example, one of his notebooks has military “drawings of possible submarines, black-sailed stealth ships, and steam-powered cannons, as well as some architectural designs for churches and ideal cities.” Because paper was expensive, “Leonardo tried to use every edge and corner of most pages, cramming as much as possible on each sheet and jumbling together seemingly random items from diverse fields.”

ONE SHEET

Focusing on just one large page from his notebooks can illuminate the way Leonardo’s mind worked. On one page is a bust of a “semiheroic, craggy old man with a long nose and jutting chin,” a recurring character in Leonardo’s work. Below him is a drawing of a tree, perhaps an analogy for the human circulatory system. Flowing out of the man’s

back is a geometric design, likely drawn because “Leonardo was beginning his long attempt to solve the ancient mathematical challenge of ‘squaring the circle,’ constructing a square that has the same area as a given circle using only a compass and straightedge.” The geometric drawing flows into a sketch of a mountain. “The result is a seamless connection of geometry to nature and a glimpse into Leonardo’s art of spatial thinking.”

Also on the page are sketches of a horse monument for Ludovico Sforza, a couple of mechanical devices, a walking horse, leaf studies, cumulous clouds, falling water, a church’s belltower, curls of hair, foliage and “a lily emerging from swirls of grass.” The outlying element is a recipe for making blond-brown hair dye, perhaps a rare personal note.

06

CHAPTER SIX

COURT ENTERTAINER

PLAYS AND PAGEANTS

“Leonardo da Vinci’s entrée into the court of Ludovico Sforza came not as an architect or engineer but as a producer of pageants.” As a great admirer of Florence’s rich culture of public spectacle, Leonardo “had become enthralled by staging fantasies, a talent that also happened to be much in demand in Sforza’s Milan court, which thrived on plays and public entertainments” since they served to legitimize Sforza rule. One of Leonardo’s significant contributions was for a play at the wedding of Gian Galeazzo Sforza, the nominal duke and nephew of Ludovico. For the celebration, he designed a half-egg dome covered in gold and torches in the shape of the constellations.

The next year, at the celebration of Ludovico’s marriage to Beatrice d’Este, Leonardo created a fantastical scene: “‘First a wonderful steed appeared, all covered with gold scales which the artist has colored like peacock eyes,’ Ludovico’s secretary recorded. ‘Hanging from the warrior’s golden helmet was a winged serpent, whose tail touched the horse’s back.’” Also present were a horde of men dressed as cavemen. “It was typical of Leonardo’s desire to indulge in the scary and exotic.” His passion for the mechanical contraptions behind the effects were as strong as his passion for art, “and he saw them as connected.” This work gave him fame and financial compensation, “but it also served a larger purpose. It required him to execute his fantasies.”

MUSIC

As an established lyre player, Leonardo's original pretense for coming to Milan was his musical talent. "His repertoire ranged from the classical love poems of Petrarch to witty lyrics he concocted himself, and he won a contest in Florence with one of his performances." Yet he never wrote down compositions, it seems, preferring instead to improvise. As part of his pageant work, he continued to dream up new instrument designs, sketching up ways to produce different tones and notes from a single bell or drum using dampers, hammers and multiple holes. His most ambitious design was the *viola organista*: a combination of a violin and an organ, with a bow, like a stringed instrument, that was moved mechanically.

ALLEGORICAL DRAWINGS

Leonardo made a series of drawings extolling the virtues of Ludovico at this time as well. Envy is a recurring character in many of these drawings, perhaps portraying Leonardo's own moral struggles. In some of the drawings, Ludovico is depicted as Envy's nemesis and "is shown holding out a pair of eyeglasses to unmask her lies as she cowers away from him. 'Il Moro with spectacles, and Envy depicted with False Report,' Leonardo captioned the drawing."

THE GROTESQUES

For the Sforza court, Leonardo also produced a series of "visi monstruosi" (monstrous faces)," which are also known as his "grotesques." They show fanciful, ugly faces on paper about the size of a credit card and serve as "examples of how Leonardo's observational skills became fodder for his imagination." He drew inspiration from people he would invite to share a meal, where he would tell them ridiculous stories, observe their faces as they laughed and then create exaggerated caricatures. Other times, he would just wander around, looking for people with unique or otherwise notable facial features. "These face-finding excursions, along with the sketches that resulted, helped Leonardo in his quest to find ways to relate facial features to inner emotions." On his fascination with physiognomy, Leonardo wrote, "'Characteristics of the face partly reveal the character of men, their vices and temperaments.'"

LITERARY AMUSEMENTS

At least 300 of Leonardo's literary works survive, many from his time at the Sforza court, "produced to provide entertainment whenever the occasion warranted." Some are fables, similar to those of Aesop, meant to illustrate some sort of moral lesson. "Closely related are the entries in his bestiary, a compendium of short tales of animals and moral lessons based on their traits." Another type Leonardo called "prophecies," which were more like riddles or jokes than predictions of the future. Leonardo loved puns and practical jokes as well, including one where he compressed cow intestines and then suddenly inflated them with a pair of chimney bellows, filling the room.

One of his fantasy novellas followed the exploits of a giant that terrorized North Africa. "The tale is an early example of a theme that Leonardo would return to repeatedly until the end of his life: cataclysmic scenes of destruction and deluge that consume all earthly life." Another story revolves around a great flood that engulfs a city; an engineer defeats the storm by "building a huge drainage tunnel through the Taurus Mountains."

07

CHAPTER SEVEN

PERSONAL LIFE

OUTSTANDING BEAUTY AND INFINITE GRACE

“Leonardo became known in Milan not only for his talents but also for his good looks, muscular build, and gentle personal style.” His biographers and contemporaries alike recorded the charm and graciousness of his personality and interactions. He dressed colorfully and grew a long beard that was “‘well-dressed and curled.’” Generous with his material possessions, he instead focused on the more esoteric rewards from his intellectual and artistic endeavors and took great pleasure in his horses and animals in general, allegedly even purchasing birds just to set them free. This love of animals was reflected in his vegetarianism and his writings against eating meat, a morality derived from the fact that animals feel pain.

SALAI

On July 22, 1490, when Leonardo was 38 years old, Gian Giacomo Caprotti came to his estate. The boy was 10 years old, and Leonardo described him as his pupil, but Caprotti also served as a model for drawings, as an assistant and as a companion. He would soon gain the nickname of Salai, “Little Devil.” Through the years, Leonardo would record Salai’s petty thefts and misbehavior in an exasperated but seemingly amused tone. Nevertheless, he “continued, throughout his life, to indulge Salai and dress him in colorful and dandy clothes, many of them pink, the costs of which (including at least twenty-four pairs of fancy shoes and a pair of stockings so expensive they must have been jeweled) would routinely be recorded in his notebooks.”

DRAWINGS OF OLD AND YOUNG MEN

“Even before Salai moved in with him, Leonardo began what would be a lifelong pattern of juxtaposing sketches of an androgynous, curly-haired pretty boy facing a craggy older man ... with a jutting chin and aquiline nose.” He found the natural contrast compelling—something that he picked up from Verrocchio. After Salai came to live with him, a different kind of boy appears in his drawings, presumably modeled after Salai. The young boy in the drawings ages throughout the years, adding further credence to the idea that he was based on Salai. One depiction has the Salai-like boy intertwined with the older man, meant to represent the concepts of pleasure and pain. “‘Pleasure and Pain are represented as twins,’ Leonardo wrote on the drawing, ‘because there never is one without the other.’”

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CHAPTER EIGHT

VITRUVIAN MAN

A *TIBURIO* FOR MILAN'S CATHEDRAL

In 1487, Milan was looking to add a *tiburio* (a lantern tower) to its cathedral and therefore established a competition to solicit the best design. Looking to distinguish himself as an artist and an architect, Leonardo began working on proposals to present to the Milanese authorities. For his work, he received payments for analyzing the structural issues inherent to adding a tiburio and devising a system of buttresses that would maintain the integrity of the structure, even suggesting a double-shelled dome. In the process, he collaborated with Donato Bramante and Francesco di Giorgio, two of the best artist-engineer-architects in the city. Eight years Leonardo's elder, "Bramante served as the initial expert judging the tiburio submissions."

Having connected over their shared origins in the Sforza court, Leonardo and Bramante began "working together on fantasias performed for special occasions and other effusions of the Sforza entertainment industry." The pair would also later collaborate on a painting of Heraclitus and Democritus, and when Ludovico Sforza commissioned Bramante to rework the convent of Santa Maria delle Grazie, Leonardo was given the task of painting the Last Supper on the wall.

FRANCESCO DI GIORGIO IS CALLED IN

With proposals from Leonardo and other architects in hand, the Milanese officials were still unsure about whose proposal to choose for the tiburio atop the cathedral. So to decide, they called in an expert, Francesco di Giorgio from Siena, whose interests in painting, architecture, urban design, sculpture and military weapons closely matched those of Leonardo. Under Francesco's guidance, the city of Milan chose the designs of "two local architect-engineers who had been part of the competition," and Leonardo was forced to withdraw his submission—though he continued to remain interested in church design. "His most interesting church designs featured floor plans that imbedded circles inside squares to form a variety of shapes, with the altar in the center, which were intended to evoke a harmonious relationship between man and the world."

A TRIP WITH FRANCESCO TO PAVIA

In the midst of the Milanese tiburio project, in June 1490, Leonardo and Francesco took a trip to Pavia to act as consultants on the town's own cathedral. "Francesco was at that time revising the manuscript of his treatise on architecture, and he discussed it with Leonardo as they traveled together. ... They also discussed another, more venerable book. In the thousand-volume Visconti library in the castle in Pavia there was a beautiful manuscript copy of an architectural treatise by Vitruvius."

VITRUVIUS

Marcus Vitruvius Pollio was born around 80 B.C., and served in Julius Caesar's military, designing and constructing artillery. Later, he "became an architect and worked on a temple ... in the town of Fano in Italy. His most important work was literary, the only surviving book on architecture from classical antiquity: *De architectura*, known today as *The Ten Books on Architecture*." In the early 1400s, Vitruvius was rediscovered by Poggio Bracciolini, who sent an eighth-century copy of *De architectura* to Florence. "What made Vitruvius's work appealing to Leonardo and Francesco was that it gave concrete expression to an analogy that went back to Plato and the ancients, one that had become a defining metaphor of Renaissance humanism: the relationship between the microcosm of man and the macrocosm of the earth."

“Applying this analogy to the design of temples, Vitruvius decreed that the layout should reflect the proportions of a human body, as if the body were laid out flat on its back upon the geometric forms of the floor plan.” He described in detail the perfect proportions of the “well-shaped man,” ultimately creating a formula for how “to put a man in a circle and square in order to determine the ideal proportion of a church.”

DINNER WITH GIACOMO ANDREA

A month after Leonardo and Francesco returned from their trip to Pavia, where they inspected the Vitruvius manuscript, they had dinner with Giacomo Andrea, another architect at Ludovico’s court. From their conversation at dinner, “Andrea decided to try his own hand at illustrating Vitruvius’s idea” and “produced a simple version of a spread-armed man in a circle and a square. ... Notably, the circle and square are not centered; the circle rises higher than the square.”

LEONARDO’S VERSION

Unlike those of Andrea and Francesco, Leonardo’s version of *Vitruvian Man* “is meticulously done. His lines are not sketchy and tentative. Instead, he dug hard with his stylus ... as if he were making an etching. ... Using a compass and a set square, he drew the circle and the square, then allowed the man’s feet to rest comfortably on them. As a result, per Vitruvius’ description, the man’s navel is in the precise center of the circle and his genitals are at the center of the square.” Fastidious notes about the dimensions and calculations accompany the drawing; worth noting are the ways he diverged from Vitruvius’s prescriptions, choosing instead to devise his own proportions.

COLLABORATION AND *VITRUVIAN MAN*

While many argue over how much credit is due to any project Leonardo worked on, Isaacson believes every project to be a product of collaboration. “Conceiving ideas was for Leonardo, as it has been throughout history for most other cross-disciplinary thinkers, a

collaborative endeavor. ... This process of bouncing around thoughts and jointly formulating ideas was facilitated by hanging around a Renaissance court," like Ludovico Sforza's court in Milan, where Leonardo encountered a wide variety of people with diverse interests and passions, allowing him to stumble upon ideas serendipitously.

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CHAPTER NINE

THE HORSE MONUMENT

A RESIDENCE AT THE COURT

In the spring of 1489, Leonardo received word that he had been awarded the commission to create an enormous horse monument commemorating Ludovico Sforza's father. "The commission, along with his service as an impresario and designer of court pageants, finally earned Leonardo an official appointment at court, with a salary and accommodations." His stipend was enough to sustain two assistants and three to four students, and he was also given "an income-producing vineyard just outside of Milan, which he kept for the rest of his life." It was at this time, living in the Corte Vecchia, that he devised several home conveniences: adjustable window blinds, easels on pulleys and a system to protect his artwork at night.

DESIGNING THE MONUMENT

The monument "was intended to be a bronze horse and rider weighing seventy-five tons, which would have been the biggest one yet made." It would measure 23 feet in height, almost twice as large as recent equestrian monuments by Verrocchio and Donatello. Leonardo would zero in on the anatomy of the horse, in particular, even going so far as to dissect a specimen to better understand its form. He would grow to obsess over horses, making many detailed drawings and studies and even planning a treatise on their anatomy. These diversions made his patron nervous, however, so he engaged in a public relations campaign,

enlisting the help of the poet Piattino Piatti, who composed an epigram for the statue's base and used his influence in the court to help Leonardo secure the commission.

In Pavia, Leonardo had seen a Roman equestrian sculpture, noting how lively it seemed. “‘The movement is more praiseworthy than anything else,’ he wrote in his notebook. ‘The trot almost has the quality of a free horse.’” In November 1493, he showed off a full-size clay model at the wedding of Ludovico's niece to the future Holy Roman Emperor Maximilian I—to great effect. All who saw it were effusive in their praise, and the model alone increased Leonardo's reputation as a sculptor and an artist.

CASTING

Most statues of this size at the time were cast in several pieces and then welded together, but Leonardo, ever ambitious, made plans to cast the whole horse in one mold. Using a clay model to create the mold, “Leonardo then tailored a ‘casting hood,’ a lattice iron frame that would be strapped around the outside of the mold like a corset to hold it together and keep it in shape.” For the mold filler, he experimented with various materials, positions and pouring techniques. But in 1494, the bronze meant for the statue was sent to the city of Ferrara for cannons to defend against the invasion of French King Charles VIII, and Leonardo's statue was never made.

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CHAPTER TEN

SCIENTIST

TEACHING HIMSELF

Leonardo took particular pride in being self-taught, valuing experience and experimentation over formal instruction. “The education that Leonardo was soaking up in Milan, however, began to soften his disdain for handed-down wisdom.” In the 1490s, he even tried to learn Latin, which he never truly mastered. Fortunately, in 1452, Johannes Gutenberg had begun selling mass-printed Bibles, and in 1469, Johannes de Spira moved to Venice and founded Italy’s first major commercial publishing house, making literature more affordable and widely accessible. And “by 1471 there were printing shops also in Milan, Florence, Naples, Bologna, Ferrara, Padua, and Genoa.”

As a great lover of books, Leonardo owned “forty works of science, close to fifty of poetry and literature, ten on art and architecture, eight on religion, and three on math,” by 1504. To supplement his literary appetite, he also “liked to pick people’s brains” and was constantly asking his acquaintances questions.

CONNECTING EXPERIMENT TO THEORY

“Leonardo’s devotion to firsthand experience went deeper than just being prickly about his lack of received wisdom. It also caused him, at least early on, to minimize the role of theory.” Instead, he preferred to use his observations to create theories and hypotheses, and this empirical approach made him particularly forward-thinking at the

time. By basing his science on observations, he was able to discern patterns and then test “their validity through more observations and experiments.” In the 1490s, he began to realize “the importance of being guided not only by experiential evidence but also by theoretical frameworks.” In the Milanese *tiburio*, for example, he combined the two methods by using physics to understand the structural issues of the project and then devising practical experiments to test his own theories.

PATTERNS AND ANALOGIES

In his thinking, Leonardo relied heavily on the use of analogy to understand and describe patterns in nature. For instance, when he was inventing musical instruments, he made an analogy between how the larynx works and how a glissando recorder could perform similarly. And while “competing to design the tower for Milan’s cathedral, he made a connection between architects and doctors that reflected what would become the most fundamental analogy in his art and science: that between our physical world and our human anatomy.” This kind of thinking led him to pen “*da Vinci’s rule*,” stating that “All the branches of a river at every stage of its course, if they are of equal rapidity, are equal to the body of the main stream.”

CURIOSITY AND OBSERVATION

Two of Leonardo’s greatest abilities involved his dogged curiosity and almost uncanny skills of observation. “His curiosity was aided by the sharpness of his eye, which focused on things that the rest of us glance over,” leading him to prove that “objects look smaller when surrounded by light and look larger in the mist or dark.” In his notebooks, he detailed one of his techniques for observation, which involves looking at an object detail by detail instead of as a whole. “Deep observation must be done in steps: ‘If you wish to have a sound knowledge of the forms of objects, begin with the details of them, and do not go on to the second step until you have the first well fixed in memory.’”

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CHAPTER ELEVEN

BIRDS AND FLIGHT

THEATRICAL FLIGHTS OF FANCY

“For more than two decades, beginning around 1490, Leonardo investigated, with an unusual degree of diligence, the flight of birds and the possibility of designing machines that would enable humans to fly.” From this period came more than 500 drawings and 35,000 words in a dozen notebooks, an effort that “took him closer than most of his other investigations into the realm of pure theory, including fluid dynamics and the laws of motion.” His initial interest arose from his work on creating fantastical machines for the stage in Verrocchio’s bottega. Early projects included a featherless wing powered by pulleys and bat-like wings with cranks for motion but not actual flight.

BIRD-WATCHING

He fueled his studies by watching birds and discerning, for example, that some birds differed the speed with which they flapped their wings when flapping upward versus downward. Relying on his observations while watching birds take flight, he was able “to make a generalization about the relationship between a bird’s tail and its wings: ‘Birds with short tails have very wide wings, which by their width take the place of the tail.’” After two decades of such observations, he compiled his notes into an 18-folio collection, now known as the *Codex on the Flight of Birds*.

In compiling the codex, he expanded his study to the science of winds and, by extension, water. He also explored gravity, discovering ways to calculate an object's center of gravity. His work also led to rudimentary versions of Newton's Third Law of Motion, Bernoulli's principle and Galileo's principle of relativity.

"But like much of Leonardo's work, the treatise remains unfinished."

FLYING MACHINES

"Both his observations on anatomy and his analysis of the physics convinced Leonardo that it was possible to build a winged mechanism that would allow humans to fly." In the late 1480s, he began to put his theories to the test by building machines with oars and bat-like wings, and he also designed gliders. His experiments took place in what he called "'la mia fabrica' (my factory)" at the Corte Vecchia. "But for all the beauty of his art and all the ingenuity of his designs, he was never able to create a self-propelled human flying machine."

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CHAPTER TWELVE

THE MECHANICAL ARTS

MACHINES

Leonardo saw a natural similarity in machines and the human body, since each operates through the interactions of smaller parts to achieve motion and movement. He showed specific interest in the part-by-part analysis of machines. “One particularly elegant drawing ... shows a spiral gear equalizing the speed of an unwinding barrel spring and transmitting the constant power to a wheel that pushes a shaft steadily upward.” He explored the interaction of humans and machines, breaking the body into components to understand and depict the transfer of energy and to calculate how much power each part could generate. One of his inventions for grinding needles could have proved highly lucrative, but he abandoned it after conception—as he often did.

PERPETUAL MOTION

“Leonardo understood the concept of what he called impetus, which is what happens when a force pushes an object and gives it momentum.” His ideas could even be seen as a preliminary theory of inertia, which Newton would ultimately refine. But for Leonardo, this idea led him to pursue the possibility of perpetual motion: a theory that supposes that if “you were able to eliminate all forces slowing down an object in motion, then it should be possible ... for a body to stay in motion forever.” While he was particularly “intrigued by the possibility that water devices might be a way to achieve perpetual motion,” he ultimately deemed the task impossible.

FRICTION

Eventually Leonardo concluded that it was resistance to motion—what we know as friction and air or water resistance—that made perpetual motion unachievable. “Through a set of experiments with heavy objects moving down a slope, he discovered the relationship among three determinants of friction: the weight of the object, the smoothness or roughness of the incline’s surface, and the steepness of the incline.” In his studies, he made many discoveries and began using oil in his machines in addition to ball and roller bearings. He “was also the first person to record the best mix of metals to produce an alloy that reduces friction.” The aggregate effect of all of this work produced in Leonardo a mechanistic view of the world, which allowed him to forge connections between physical phenomena by breaking everything down into smaller, interacting parts.

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CHAPTER THIRTEEN

MATH

GEOMETRY

“Leonardo increasingly came to realize that mathematics was the key to turning observations into theories. ... ‘There is no certainty in sciences where mathematics cannot be applied,’ he declared.” While he was naturally drawn to geometry, his skills with numbers and algebra were not as polished. “Geometry also had the advantage of being a visual endeavor,” which made it an innate strength. In lieu of mathematical calculations, he would often use shapes to illustrate “the rate of change caused by a variable.”

LUCA PACIOLI

“One of Leonardo’s close friends at Milan’s court was Luca Pacioli, a mathematician who developed the first widely published system for double-entry bookkeeping.” Pacioli only attended an abacus school, like Leonardo, but would go on to write a math textbook in Italian, which “became part of the explosive spread of learning in vernacular languages triggered by the printing press in the late fifteenth century.” He would also move into the Corte Vecchia where, together, he and Leonardo would create brainteasers, riddles and puzzles for the amusement of the Milanese court. Pacioli taught Leonardo Euclidean geometry and attempted to teach him math. In exchange, Leonardo provided illustrations for Pacioli’s *On Divine Proportion*, which focused on the golden ratio.

TRANSFORMATION OF SHAPES

“As an artist, Leonardo was particularly interested in how the shapes of objects transformed when they moved.” From observing water, he realized that volume is conserved between shapes. He applied this understanding to his depictions of human bodies in motion and also to geometry by exploring how a circle might be transformed into a square. “By grappling with these transformations and persistently recording his insights, Leonardo helped to pioneer the field of topology, which looks at how shapes and objects can undergo transformations while keeping some of the same properties.” After declaring to write a treatise on the topic of transformation, his proposed book was never completed.

SQUARING THE CIRCLE

Leonardo was fascinated with a geometrical fact discovered by Hippocrates that involved drawing overlapping half-circles to create a crescent shape, and then using a right triangle to determine the area of the crescent. “Year after year, he relentlessly pursued ways to create circular shapes with areas equivalent to triangles and rectangles.” And instead of relying on the irrational cube root of two, he discovered a way to use geometry to calculate how to double the size of a cube. He also obsessed over the challenge of squaring a circle: using only a compass and a ruler to construct a square that has the exact same area as that of a given circle.

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CHAPTER FOURTEEN

THE NATURE OF MAN

ANATOMICAL DRAWINGS (FIRST PERIOD, 1487–1493)

Primarily in service of his art, Leonardo was a great student of human anatomy. As such, he took to heart the ideas of Alberti, who instructed artists to draw bones first, then muscle and then skin to create the most life-like forms. Ultimately, though, Leonardo's interest proved to be more than just artistic, and he began engaging in dissections and medical anatomical studies in Milan. His notebooks are filled with detailed descriptions of how to depict tissue, veins, muscles and nerves accurately from multiple angles.

THE SKULL DRAWINGS

“Leonardo's initial anatomy studies of 1489 focused on human skulls.” One such drawing shows two halves of a human skull, with the front left half also sawed off. The innovation lies in the fact that the two halves are shown next to one another, thereby more easily showing the interior structure underlying the superficial structures of the face. Another diagram shows two intact halves of a skull, drawn in profile and rendered in typically beautiful fashion. His studies even accurately described human dental anatomy. But “[in] the mid-1490s Leonardo put aside his work on anatomy,” and it was another decade until he returned to the subject.

STUDIES OF HUMAN PROPORTION

In studying the proportions of cathedrals and conducting research for the Sforza equestrian statue, Leonardo became interested in human proportion and comparative anatomy. “So in 1490 he began measuring and drawing the proportions of the human body. Using at least a dozen young men as models in his Corte Vecchia studios, he measured each body part from head to toe and produced more than forty drawings and six thousand words.” Much like Vitruvius, Leonardo calculated the average and relative sizes of body parts, and he also made detailed descriptions of what happens to the body when it moves and twists.

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CHAPTER FIFTEEN

VIRGIN OF THE ROCKS

THE COMMISSION

Before being taken on at the court of Milan, Leonardo “probably shared a studio with Ambrogio de Predis, one of Ludovico’s favorite portrait artists, and his half-brothers, Evangelista and Cristoforo.” They received a joint commission to paint altarpieces for the Franciscan church where the Confraternity of the Immaculate Conception gathered to worship. The painting was supposed to show the Virgin Mary with baby Jesus surrounded by angels and the “two Prophets.” Instead, Leonardo produced two versions that feature John the Baptist and are now known as the *Virgin of the Rocks*.

THE FIRST VERSION (LOUVRE)

As a narrative piece, the first version of the *Virgin of the Rocks* creates movement through hand motions and gestures, directing attention from the angel to John, then to baby Jesus and Mary and then to the left hand of the angel holding Jesus, whose hand is touching the ledge of a rocky precipice over a pond. “The angel’s pointing finger is the main feature that distinguishes the first version from the second.” But modern analysis shows that the hand gesture was not initially included in the first version’s underdrawing, as Leonardo likely found it awkward—which an observer may notice. “Redeeming the narrative flow are the fluid areas of light, which give the painting a sense of unity. In this masterpiece, Leonardo ushered in a new era of art in which light and shade are juxtaposed in a manner that produces a powerful sense of flow.”

Paying special attention to the natural elements in the painting, Leonardo included the rocks behind Mary, which are geologically accurate examples of both sedimentary and volcanic igneous rock that would have existed in 1485, the year the painting was finished. “The plants in the picture are located, as they would be in nature, only in the sandstone regions that have weathered sufficiently to permit roots to take hold, both at the top and the floor of the grotto,” and “the species chosen are botanically and seasonally correct.”

THE SECOND VERSION (LONDON)

During the 1490s, Leonardo and Ambrogio de Predis worked on a new version of *Virgin of the Rocks* for the Confraternity of the Immaculate Conception, after the first version failed to be delivered to them, as it was most likely sold to someone else. In the later version, the angel is no longer pointing and is looking at the scene, rather than at the viewer. “Another subtle difference is that the grotto is more closed and there is less sky above. The light is therefore not as diffused but instead comes in directionally as a beam from the left side of the painting, selectively falling upon and highlighting the four characters.” Though it’s widely attributed to Leonardo, upon deeper inspection, it would seem that some of the painting might not have been done by Leonardo: The rocks in the background do not display the dedication to realism shown in the first version, and the plants are similarly fantastical rather than botanically accurate.

TEAMWORK

While it is tempting to think of an artist’s work as a solitary effort, the truth is that Leonardo had been trained in Verrocchio’s bottega, where collaboration was the norm. Even in his own studio, Leonardo turned to producing multiple works at a time, delegating work to his students, then adding final touches.

HEAD OF A YOUNG WOMAN

The angel in *Virgin of the Rocks* “is an example of Leonardo’s proclivity for gender fluidity,” and the “androgynous nature of the figure is

heightened by comparing the angel to what is generally regarded as a preparatory study for it, a drawing by Leonardo, called *Head of a Young Woman*.” This drawing displays Leonardo’s genius as a draftsman, using a silverpoint stylus on paper coated in a thin layer of pigment.

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CHAPTER SIXTEEN

THE MILAN PORTRAITS

PORTRAIT OF A MUSICIAN

Painted in the mid-1480s, *Portrait of a Musician* is Leonardo's only portrait of a man. Intriguingly, there are no mentions of it anywhere, leaving both the identity of the man and the purpose of the painting complete mysteries. It remains unfinished, with a notable difference in quality between the man's face and the rest of the painting. "It seems that Leonardo simply decided, on his own, to paint the young man." Leonardo's connection to the subject, if there was one, remains unknown. Further, the painting displays an uncharacteristic harshness of light, suggesting that Leonardo did not add all of the thin layers of oil paint that he usually would have by the time a piece was finished.

CECILIA GALLERANI, THE *LADY WITH AN ERMINE*

"Cecilia Gallerani was a striking beauty who was born into Milan's educated middle class. ... Cecilia composed poetry, delivered orations, wrote letters in Latin, and would later have two novels by Matteo Bandello dedicated to her. In 1482, when she was ten her brothers were able to arrange a promising marriage contract for her to Giovanni Stefano Visconti, a member of the family that once ruled Milan." But four years later, the marriage contract was dissolved on account of a lack of dowry payments.

By the time she was 15 years old in 1489, Cecilia was living in a house provided by Ludovico Sforza, and a year later she was pregnant with

his son. *Lady with an Ermine* was commissioned at the height of the relationship, in 1489, when Ludovico asked Leonardo to paint a portrait of Cecilia.

Depicted in three-quarters view, her body was turned to the left and her face to the right, an ermine squirming in her arms. The pose and expression, even of the ermine, display emotion and a liveliness that had hitherto not been seen in portraits of the day. The ermine evokes purity and is a subtle nod to Ludovico, who had received the Order of the Ermine by the king of Naples. Cecilia's expression is subtle, with the hint of a smile that seems to express different emotions all at once. "As Leonardo portrayed the motions of her mind and soul, he played with our own inner thoughts in a way that no portrait had done before."

Shortly after the painting's completion, the relationship between Cecilia and Ludovico dissolved—as was expected, since Ludovico had been contracted to marry someone else. In 1491, Ludovico married Beatrice d'Este, who had been betrothed to him since the age of five, and he arranged for Cecilia to be married off to a wealthy count.

LA BELLE FERRONNIÈRE

Leonardo's continued fascination with the depiction of reflected light is seen in another portrait from this period—that of a woman in the Sforza court—known as *La Belle Ferronnière*. Although unconfirmed, the subject is most likely Lucrezia Crivelli, another of Ludovico's mistresses. In this painting, the light shines down on Lucrezia from the top left, creating a reflection off her shoulder and a strangely colored play of light on the edge of her left jaw. "Leonardo was then deeply immersed in his scientific study of how light varies according to the angle at which it strikes a curved surface. ... In this portrait, Leonardo also continued to experiment with his haunting method of creating a stare or gaze that seems to follow a viewer around a room," giving the subject a particularly intense stare. Yet with the subject's flat and dull hair, rigid pose and plain adornments, the piece doesn't display the usual flairs that made Leonardo's work stand out. Isaacson concludes, "Perhaps it was a collaborative work of his studio, produced to fulfill a ducal commission, with some involvement from Leonardo's brush but not his heart and soul."

PORTRAIT OF A YOUNG FIANCÉE, ALSO KNOWN AS LA BELLA PRINCIPESSA

Yet another of Leonardo's purported portraits, *Portrait of a Young Fiancée* depicts a young woman in profile. Since 1998, however, when it was up for auction and came to the attention of a determined art collector named Peter Silverman, its provenance has remained in question. Convinced of its legitimacy, Silverman began his attempt to prove that it was painted by Leonardo by showing it to various connoisseurs of Renaissance art. With experts divided, Silverman then turned to a carbon-24 test, which determined that the vellum the work was painted on was dated to between 1440 and 1650. In Paris, a company named Lumiere Technology next analyzed the painting using extremely high-definition photos, allowing them to view up to 1,600 pixels per millimeter and compare the painting to known works by Leonardo. After finding that "[the] subject's dress and her ... hairstyle indicate that she was connected to Ludovico Sforza's court in Milan in the 1490s," further research suggests it may have been Bianca Sforza, the duke's illegitimate daughter, who was married to the commander of Ludovico's military and a known friend of Leonardo.

At this point, a forensic art examiner named Peter Paul Biro was brought in. He claimed to have found a fingerprint on the painting that matched a fingerprint from *Saint Jerome in the Wilderness*. But in 2010, Biro was the subject of a profile in *The New Yorker* that, among other things, brought to light Biro's past scandals, including accusations of fraud and extortion, severely undermining his credibility as an examiner.

In another twist, Pascal Cotte, the founder of Lumiere Technology, revealed that the painting seems to have been cut out of a book, consistent with the fact that it was completed on vellum. When a retired professor informed the team of a volume located in Warsaw's National Library of Poland, researchers discovered that the portrait's torn edges matched those of the book: a history of the Sforza family commemorating the wedding of Bianca. While the exact origins of the portrait remain uncertain, Isaacson confirms that "the tale of *La Bella Principessa* provides us with some insights into what we do and do not know about Leonardo's art."

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CHAPTER SEVENTEEN

THE SCIENCE OF ART

THE *PARAGONE*

On February 9, 1498, Leonardo participated in a *paragone*, a “staged debate on the comparative value of various intellectual endeavors,” which was largely seen as “a way for artists and scholars to attract patrons and elevate their social status during the Italian Renaissance.” In his speech arguing for the primacy of painting as the highest of the liberal arts, Leonardo linked the work of artists to “the science of optics and the mathematics of perspective.” He argued “that true creativity involves the ability to combine observation with imagination, thereby blurring the border between reality and fantasy”—the two concepts that great painters must depict. In participating in the debate, his goal was to demonstrate that art required both intellect and physical coordination.

FANTASIA AND REALITY

Despite—or perhaps because of—his keen skills for observing and conveying reality, Leonardo had a keen love for combining the fantastical with the hyperreal. “He relished the wonders that can be seen by the eye but also those seen only by the imagination. ... Just as he could festoon a real lizard with various animal parts to turn it into a dragon-like monster, for either a parlor trick or a fanciful drawing, he was able [to] perceive the details and patterns of nature and then remix them in imaginative combinations.”

THE TREATISE

“Duke Ludovico was so impressed with Leonardo’s paragone presentation that he suggested he write it as a brief treatise.” As with so many of his efforts, it remains unfinished, but Leonardo would add to his notes on paintings for the rest of his life. After his death, his assistant and heir Francesco Melzi compiled the notes into Leonardo’s *Treatise on Painting*.

SHADOWS

Leonardo “had first tackled the complexities of shadows when drawing draperies as an exercise in Verrocchio’s studio.” From this practice, “[he] came to understand that the use of shadows, not lines, was the secret to modeling three-dimensional objects on a two-dimensional surface. The primary goal of a painter, Leonardo declared, ‘is to make a flat surface display a body as if modeled and separated from this plane.’” This was a break from previous artists, who emphasized contour outlines. In studying shadows, Leonardo wrote extensively on their various forms and characteristics, and how to most realistically depict them.

SHAPES WITHOUT LINES

“Leonardo’s reliance on shadows, rather than contour lines, to define the shape of most objects stemmed from a radical insight, one that he derived from both observation and mathematics: there was no such thing in nature as a precisely visible outline or border to an object.” He distinguished discrete mathematical concepts—numbers and lines—from continuous ones—angles and shapes—comparing shadows and the shapes of nature to the latter category. He even went so far as to say that artists should not use lines in their work.

OPTICS

Through his research and dissections, Leonardo came to believe, correctly, that light is focused on an area in the eye (the retina), not at a point. This understanding “helped him explain why sharp lines are not visible in nature.” On the subject, he wrote, “‘The true outlines of opaque bodies are never seen with sharp precision,’ ... ‘This happens

because the visual faculty does not occur in a point; it is diffused throughout the pupil ... of the eye.’” He was, however, confused by how the eye produced images that were right-side up, when his use of a camera obscura showed that the image in the eye would be upside-down. This led him to trace the eye to the brain in dissection, furthering his understanding of anatomy and perception of light.

PERSPECTIVE

“Leonardo realized that the art of painting and the science of optics were inseparable from the study of perspective.” Invariably tied to his understanding of light, he prepared a treatise on perspective as he did research for his writing on the topics of painting and optics. The subject had been well-explored by previous scholars and artists, including Brunelleschi, whose advice Leonardo had closely followed when painting *Adoration of the Magi*. Despite extensive existent research, Leonardo’s innovation came from his work on conveying depth using changes in color and clarity, rather than just conveying distance through relative size (i.e., linear perspective). While his advancements in linear perspective were not groundbreaking, he did put forth the concept of acuity perspective by explaining that as objects recede into the background, they should also become less clear in detail.

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CHAPTER EIGHTEEN

THE LAST SUPPER

THE COMMISSION

Ludovico Sforza, now the official Duke of Milan, sought to build his family mausoleum at Santa Maria delle Grazie, a church and monastery in Milan. He commissioned Leonardo to paint *The Last Supper* on the north wall of the new refectory, or dining hall. The duke was very impatient for the painting to be finished, especially after the death of his wife in early 1497. But Leonardo's creativity was not to be rushed, and the wait seems to have been worth it.

A MOMENT IN MOTION

"Leonardo's painting depicts the reactions just after Jesus tells his assembled apostles, 'One of you will betray me.'" Although the painting is a static scene, one can see the rippling effect of Jesus' words as his disciples turn to one another, wondering who the traitor will be. "In addition to portraying the motion contained in a moment, Leonardo was masterful at conveying *moti dell'anima*, motions of the soul"—as conveyed by the apostles' hand gestures. Grouped in threes, the disciples on the left are demonstrating their initial reaction of surprise, and the motion of the painting infers that the news moved left to right. In the center, Jesus is slightly smaller than everyone else, but his size is disguised by the light behind him, as "objects against a light background look larger than when against a dark background." Jesus' gestures subtly point to wine and bread, foreshadowing the ritual that would come to inspire the Eucharist or Communion.

PERSPECTIVE IN *THE LAST SUPPER*

Jesus' forehead serves as the point at which the linear perspective lines converge, also known as the vanishing point. The tapestries on the wall "were painted in a way that made them appear to be in line with the real tapestries in the actual dining hall, thus creating the illusion that the painting was an extension of the room." But the painting is different based on whether you are viewing it from the left or the right. Because the room was not large enough to accommodate an ideal viewing distance of 15 to 20 times the size of the painting, Leonardo created an artificial vantage point 30 feet back and 15 feet high, at eye level with Jesus. Using various tricks, he also "fudged slightly so that the perspective looks natural when viewed from a door to the right wall from which the monks entered."

To disguise this adjusted perspective, he hid the floor lines with the table and painted a ceiling molding that prevents it from extending all the way over the table. "This use of accelerated perspective, in which the walls and ceilings recede toward the vanishing point more quickly than normal, was one of the many tricks that Leonardo learned from the theatrical events he produced."

DETERIORATION AND RESTORATION

Using a mixture of oil and tempera, Leonardo attempted to get around the usual method of painting on a wall, which required that he complete each section in one day while the plaster was still wet. Yet within about 50 years, the painting had been almost completely degraded. Attempts at restoration were met with strong opposition and found only middling success at restoring the original grandeur. The most recent restoration began in 1978 and wasn't completed until 1999. The leader of the effort attempted to use infrared reflectoscopy and microscopic samples, in addition to extant copies of the painting made during Leonardo's lifetime. The result was met with mixed criticism and praise.

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CHAPTER NINETEEN

PERSONAL TURMOIL

CATERINA'S DEATH

In July 1493, Leonardo's mother Caterina came to live with him. Around 1490, her husband Accattabriga and son had died, and in the summer of 1494, she died of malaria, according to an official record. After his mother's death, "Leonardo sublimated whatever emotions he felt" and recorded little about the event in his notebooks aside from the cost of the funeral. On the listing of funeral expenses, "he even crossed out the word 'death' and wrote 'burial.'"

CAREER STRUGGLES

At the time he began painting *The Last Supper*, around 1495, Leonardo was at the peak of his career. But in the late 1490s, Ludovico became preoccupied with the French threat, and Leonardo "found himself doing interior design work and engaging in disputes over pay and performance." One notable squabble with the duke involved a painting on the ceiling of one of Ludovico's private rooms, which Leonardo seems to have taken on in the middle of painting *The Last Supper* as a way to make some money.

When Ludovico fled Milan in the summer of 1499, Leonardo worked with the French invaders. He even "forged a secret deal with the new French governor of Milan, Louis de Ligny, to meet him in Naples and act as a military engineer inspecting fortifications." Yet this never came to pass, and Leonardo made his way back to Florence after hearing that Ludovico was planning a comeback.

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CHAPTER TWENTY

FLORENCE AGAIN

THE RETURN

In early 1500, Leonardo began his trip back to Florence. Along the way, he stopped at Mantua at the house of Isabella d'Este, the sister of Ludovico's late wife Beatrice. There, he made a chalk drawing for her portrait. He then went to Venice, "where he offered military advice on defending against a threatened Turkish invasion." Among his ideas were "a mobile wooden lock that he believed could allow the Isonzo River to flood a valley that would be used by any invaders" and an army of underwater soldiers. In late March 1500, he reached Florence, which had recently recovered from a religious rebellion led by Girolamo Savonarola, who had instituted a fundamentalist regime that had encouraged the burning of paintings and books and imposed moral order by organizing patrols. Leonardo would stay in the city until 1506.

LIFE AT FIFTY

Nearing the age of 50, Leonardo firmly set aside any attempts to conform. He dressed dandily and made sure Salai was finely and flamboyantly dressed as well. He continued to expand his personal library, adding volumes on Euclidean geometry, Aesop's fables, bawdy poems and a book on architecture by Francesco di Giorgio, his collaborator on the Milanese tiburio.

ISABELLA D'ESTE'S UNPAINTED PORTRAIT

Isabella d'Este was 26 years old when she first started communicating with Leonardo about a possible commission. Much of their back-and-forth centered on whether the work would be a fleshing out of the portrait he drew in chalk when visiting in Mantua or depicting another subject of his choosing. With “a rigorous classical education in Latin, Greek, history, and music,” Isabella had initially garnered the interest of Ludovico, but instead married Francesco Gonzaga, the Marquess of Mantua, to whom she had been betrothed since early childhood. Extraordinarily wealthy, she was a great purveyor of luxury, with a particular taste for art and paintings of herself. A string of paintings she had commissioned were dismissed as making her look too fat or otherwise less beautiful than she viewed herself. After Francesco gave away her original chalk drawing, she asked Leonardo to send her the copy he made, which shows her in profile, as was typical of royal portraits.

To lobby Leonardo to complete the portrait, Isabella would enlist the help of Pietro da Novellara, a friar. In a letter, Pietro told Isabella of Leonardo's preoccupation with geometry and lack of interest in painting. Leonardo would continue to rebuff Isabella's entreaties, at times not even sending responses. In 1504, she asked instead for a painting of Jesus at the age of 12, but she was again unsuccessful. In 1505, she rejected Salai's offer to accept the commission. In 1506, she came to Florence personally but instead only met with Leonardo's stepmother's uncle, who unsuccessfully tried to convince him to complete the portrait.

MADONNA OF THE YARNWINDER

For Florimond Robertet, Louis XII's secretary, Leonardo produced a painting of a Madonna about to spin yarn, as baby Jesus grasps at the yarnwinder, which is in the shape of a cross. Many versions of the painting exist, as Leonardo's workshop produced dozens of them, just as Verrocchio's had. But in the best versions, “[the] emotional power of the *Yarnwinder* scene comes from the psychological complexity and intensity of the baby Jesus as he contemplates and grapples with the yarnwinder.”

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CHAPTER TWENTY-ONE

SAINT ANNE

THE COMMISSION

In 1501, while Isabella d'Este attempted to beguile Leonardo to paint her portrait, he was working on his masterpiece *Virgin and Child with Saint Anne*, which shows baby Jesus nearly jumping out of his mother's arms to seize a lamb, as Mary sits in her own mother's lap. "The final painting combines many elements of Leonardo's artistic genius: a moment transformed into a narrative, physical motions that match mental emotions, brilliant depictions of the dance of light, delicate sfumato, and a landscape informed by geology and color perspective." It was commissioned by the friars at the church of Santissima Annunziata, where Leonardo took up residence when he returned to Florence.

DIFFERENT VERSIONS

While "floundering in his mission to convince Leonardo to paint a portrait for Isabella d'Este," Friar Pietro wrote to her to explain that Leonardo had only completed one sketch recently, a preparatory drawing of *Virgin and Child with Saint Anne*. While this work has likely been lost, another surviving sketch, known as the Burlington House cartoon, "features Saint Anne, the Virgin Mary, and the baby Jesus, but with a young Saint John and no lamb." Since this version features a different set of characters than does Leonardo's final masterpiece, "[scores] of Leonardo scholars have puzzled over the sequencing of the various versions of the arrangement."

After extensive debate, modern art historians have determined that earlier versions included John, but he was later replaced by the lamb, revealing that Leonardo often iterated on ideas for his paintings while in the process of sketching the underdrawing.

THE PAINTING

“It is important, Leonardo wrote, to ‘have a movement of a person’s limbs appropriate to that person’s mental movements.’ His painting of the *Virgin and Child with Saint Anne* shows what he meant.” Wrestling with the lamb, the young Jesus flails his limbs as Mary gently tries, but fails, to restrain him with an outstretched arm.

As in so many of his other paintings, a river flows from the background to the foreground, connecting literally and figuratively the macrocosm of the environment with the drama of the human subjects, with the sedimentary rocks in the paintings demonstrating an acute understanding of geology.

Leonardo would never deliver this painting to the church of Santissima Annunziata, instead carrying it with him the rest of his life and making small improvements and tweaks.

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CHAPTER TWENTY-TWO

PAINTINGS LOST AND FOUND

LEDA AND THE SWAN

One of Leonardo's lost paintings, *Leda and the Swan* depicts a fully nude Leda clutching Zeus—in the form of a swan—as children emerge from eggs. Multiple completed versions exist, including those done by Leonardo's students, but the master work has yet to be positively identified. A preparatory sketch from around 1505 exists, showing all of the hallmarks of Leonardo's interest in motion.

The only known work of his to even border on the erotic, the painting focuses on the procreative aspect of sex, with lush, fertile plants playing a meaningful role in the scene.

SALVATOR MUNDI

In 2011, a previously unknown work by Leonardo emerged: *Salvator Mundi*—"Savior of the World." The painting features "Jesus gesturing in blessing with his right hand while holding a solid crystal orb in his left." Listed among Salai's estate, it disappeared when it was passed from Charles II to the duke of Buckingham, whose son sold it in 1763. In 1900, it reappeared and was purchased by a British collector, but it was sold again in 1958 for less than \$100, as it was believed to be a copy of a copy by one of Leonardo's students. Meticulous cleaning, restoration and analysis revealed signature techniques that convinced experts of its authorship, and in 2013, it sold for \$80 million before being resold for \$127 million.

Around the time he was working on this painting, Leonardo was delving into “optics studies that explored how the eyes focus. He knew that he could create the illusion of three-dimensional depth in a painting by making the objects in the foreground sharper. The two fingers on Christ’s right hand that are closest to us are drawn with a crisper delineation. It makes the hand pop out toward us, as if it’s in motion and giving us a blessing. Leonardo would reuse this technique a few years later with the pointing hands in two depictions of Saint John the Baptist.”

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CHAPTER TWENTY-TWO

CESARE BORGIA

RUTHLESS WARRIOR

“Ludovico Sforza, Leonardo’s patron in Milan, had a reputation for ruthlessness that included, among other alleged acts, poisoning his nephew in order to seize the ducal crown.” But in Cesare Borgia, Leonardo found a patron somehow more ruthless than Ludovico.

Cesare was the son of Spanish-Italian Cardinal Rodrigo Borgia, who would become Pope Alexander VI, the first pope to recognize his illegitimate children openly. He also gained a dispensation for Cesare that allowed him to hold church office, becoming the bishop of Pamplona at 15 years old and a cardinal at 18 years old. After resigning to take control of the papal forces, Cesare made an alliance with the French, marching into Milan in 1499 with King Louis XII. During the invasion, he went to see *The Last Supper*, which is most likely how he met Leonardo.

In Cesare’s quest to consolidate the Romagna region under his power, he conquered Imola, Forlì, Pesaro, Faenza, Rimini and Cesena. In 1501, “the ruling Signoria of [Florence] capitulated by agreeing to pay Borgia 36,000 florins a year as protection money and permitting his army to cross Florentine territory at will as he conquered more towns.”

NICCOLÒ MACHIAVELLI

In 1502, Cesare returned his attention to Florence, demanding that his requests be met. At this time, Francesco Solderini, a leader of the church and of an anti-Medici faction, and a young Niccolò Machiavelli were sent to Urbino, a town east of Florence. “A few days later, probably as part of his arrangement with Florence that Machiavelli had helped to negotiate, Borgia secured the services of the city’s most famous artist and engineer, Leonardo da Vinci.”

LEONARDO AND BORGIA

Leonardo’s first task for his new patron was in Piombino, where some of Cesare’s forces were stationed. There, Leonardo examined the forts and looked for ways to drain the marshes. While on assignment, he also took the time to study the waves and tides. “From there, he headed eastward across the Apennine Mountains to the other side of the Italian peninsula, gathering topographical data for maps and observing landscapes and bridges that would later be reflected in the *Mona Lisa*.” In the summer of 1502, Leonardo arrived at Cesare’s court, where he made sketches of Urbino’s palace and three red-chalk drawings of his new patron.

In September, Leonardo traveled with Cesare to Fossombrone, where he advised his patron on castle design, including a prescription that outer walls should be curved to lessen the impact of cannonballs. “He then accompanied Borgia’s army as it marched toward the Adriatic coast.” In Rimini, he was captivated by the waterfalls; in Cesenatico, “he sketched the harbor and drew up plans for defending the dykes,” in addition to directing “that the inner harbor be dredged so that it would stay linked to the sea.”

In the fall of 1502, Cesare moved his court to Imola, where the fortress had a moat 40 feet deep and walls 15 feet thick. “Borgia’s plan was to turn the town into his permanent military headquarters by having Leonardo make it even more impregnable.” During this time, Leonardo produced an aerial map of Imola and perfected his odometer design, which involved a wheel that ticked in regular intervals as it was pushed

along, dropping a rock into a wheelbarrow. “Acting as an artist-engineer, Leonardo had devised a new military weapon: accurate, detailed, and easily read maps.”

LEAVING BORGIA

Perhaps initially able to tune out Cesare’s cruelty, Leonardo eventually reached a breaking point when one of his friends was betrayed and murdered by Cesare’s men, even after complying with his demands. By March 1503, he was settled back in Florence and withdrawing money from his bank account at the hospital of Santa Maria Nuova.

Why would Leonardo, with his gentle and sensible tendencies, willingly work with a man like Cesare Borgia? Isaacson suggests, “Leonardo, who had just turned fifty, had dreamed for more than two decades of being a military engineer. ... Indifferent to the shifting political agendas of Italy yet attracted to military engineering and strongmen, Leonardo had a chance to live out his military fantasies, which he did until he realized they could become nightmares.”

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CHAPTER TWENTY-FOUR

HYDRAULIC ENGINEER

DIVERTING THE ARNO

“During his years in Milan, [Leonardo] diligently studied the city’s system of canals, and he recorded in his notebooks details of the mechanisms of the locks and other feats of water engineering.” Of particular interest to him were Milan’s artificial canals. Predating the Roman aqueducts in the Po Valley from around 200 B.C., the city’s inhabitants had used the snowmelt from the Alps for irrigation and shipping. Using his research, Leonardo began to plan a water management system for Florence. In 1494, Pisa—Florence’s only outlet to the sea—had broken away into its own republic; Christopher Columbus’ return from the West had also spurred a new interest in maritime commerce. These two factors made Florence’s desire to regain control of Pisa even more pressing.

Leonardo’s plan was to divert the Arno River from Pisa, cutting off its primary supply routes. To do so, he intended to dig large ditches and then install dams that would slowly shift the flow of water away from Pisa; a new invention of his would ease the moving of 1 million tons of dirt.

But, in August 1504, a new engineer was assigned to oversee the project, scrapping Leonardo’s ideas and his plans for the machine. While the effort failed, the project reignited Leonardo’s interest in connecting Florence to the Mediterranean Sea by creating a canal on the Arno that would bypass unnavigable rapids and waterfalls. A map from that time shows other plans to turn the marshes of the Val di Chiana into a reservoir.

DRAINING THE PIOMBINO MARSHES

In October 1504, Leonardo was sent to Piombino, a port city 60 miles south of Pisa that the Florentine authorities wished to recruit as an ally. There, he designed a fortress with three concentric walls, some of which could be flooded to create a moat during a siege. The walls were curved, as a result of Leonardo's discovery that artillery was less damaging when it struck at an oblique angle.

For draining the marshes around Piombino, he had two ideas. The first was to divert muddy water from the river into the marsh, allowing the sediment to settle and build up the land. The second was a complex design that involved creating an artificial whirlpool that would suck up water from the marsh before drawing it out to sea. As with most of his ideas, neither of these projects was ever started.

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CHAPTER TWENTY-FIVE

MICHELANGELO AND THE LOST *BATTLES*

THE ASSIGNMENT

In October 1503, Leonardo received a commission to paint a battle scene for Florence's Council Hall in the Palazzo della Signoria. His incomplete work, known as the *Battle of Anghiari*, can only be envisioned through copies, since what he painted has been lost. Michelangelo, then 28 years old and already a rival to 51-year-old Leonardo, was commissioned to paint the other mural in the hall. The space for Leonardo's mural was roughly one-third of the length of a 174-foot wall. Taking a cue from the name of the leader of Florence's council that met there—the *gonfaloniere* ("standard-bearer")—Leonardo would make "the fight for the standard at the climax of the battle" the center of his painting. Although given a play-by-play account of the battle, he "decided instead to focus on an intimate struggle of a few horsemen flanked by scenes of two other tight skirmishes."

THE CONCEPTION

"[Leonardo] paid particular attention to the colors of the dust and smoke," combining smoke from artillery and the earth and prescribing the gradient of shadow and color as the smoke rises. He wrote in even greater detail about how to portray the violence and physical pain of war, especially through the facial expressions of those he painted.

THE DRAWINGS

“The scene he finally chose for his central section was of three Florentine horsemen grappling the standard away from Milan’s defeated but still-defiant general.” Some of his drawings focused on the gruesome poses of dying soldiers. Others were intense studies of facial expressions, demonstrating his mastery of expressing human emotion. A large portion of his drawings focused solely on horses in various poses, as Leonardo attempted, successfully, to saturate even the animals and their faces with raw emotion and violence.

THE PAINTING

In light of petty squabbles over the pace of his work, Leonardo attempted to abandon the project. But in May 1504, he signed a new contract that required him to finish the painting by February 1505 or forfeit all his payment, in addition to repaying whatever he had already received. The deadline came without seeing the finished painting, and Leonardo’s experiments in making the oil paint stick to the wall were not panning out. Adding to the strife, a torrential downpour damaged the cartoon and interrupted his work. In the same room, Michelangelo was also working.

MICHELANGELO

Born in 1475, Michelangelo Buonarroti was the son of a minor noble. In 1482, he was living in the countryside with the family of a stonecutter. “During the seventeen years that Leonardo was away in Milan, Michelangelo became Florence’s hot new artist. He was apprenticed to the thriving Florence workshop of the painter Domenico Ghirlandaio, won the patronage of the Medici, and traveled to Rome in 1496, where he carved his *Pietà*, showing Mary grieving over the body of Jesus.” Described as petulant, Michelangelo seems to have had a great disdain for the older and more genial Leonardo and had known rivalries with multiple contemporaries, one of whom broke his nose, which would be crooked for life. Often disheveled, Michelangelo lived ascetically, another great contrast to the dandyish Leonardo.

It was in early 1504 that Michelangelo produced his famous statue of David. Standing at seven feet tall and depicting a nontraditionally adult David, it immediately caused a stir. A committee was convened to decide where to place it. Eventually, it would be placed at the entrance of the Palazzo della Signoria until 1873, when it would be moved inside the Accademia Gallery in Florence.

For 40 years, *David* was given a garland of brass and copper to cover his genitalia, an addition Leonardo personally lobbied for.

THE COMPETITION

Shortly after his statue of David was placed, Michelangelo was given the commission to paint a companion mural to Leonardo's in the great hall: a deliberate attempt to create competition between the two artists. Michelangelo's painting would depict the Florentine victory over Pisa in the Battle of Cascina, the scene showing nude soldiers mid-bath at the moment they heard the news of the enemy attack. Leonardo would later critique the figures as looking overly muscular—like a “sack of walnuts,” and he felt that Michelangelo “painted like a sculptor.” But turning to Michelangelo's *Doni Tondo*, Leonardo's criticism seems warranted: Twisted in motion, the “three main figures seem sculpted rather than painted; they are lifeless, and their expressions lack charm or mystery. His background features not nature but his favorite motif: male nudes. ... They are in sharp focus, with no sign of Leonardo's understanding of atmospheric or distance perspective.”

ABANDONED

In the spring of 1505, Michelangelo left for Rome to sculpt a tomb at Pope Julius II's bidding. He returned to Florence the next spring, after having a falling out with the pope. Given Leonardo's difficulties in overcoming procrastination and getting the paint to stick, he eventually abandoned his mural and returned to Milan. “Michelangelo too would leave again, kneeling to ask the pope's forgiveness and then returning to Rome. He would stay there for another decade and paint the ceiling of the Sistine Chapel.”

“SCHOOL OF THE WORLD”

Although incomplete, both Leonardo's and Michelangelo's works inspired future generations, including Raphael, who traveled to Florence just to see the cartoons. “Leonardo and Michelangelo had become luminaries, paving the way for other artists ... to do the same. ... Instead of being treated as somewhat interchangeable members of the craftsman's class, the best artists were now treated as singular stars.”

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CHAPTER TWENTY-SIX

RETURN TO MILAN

THE DEATH OF SER PIERO

In July 1504, while he was painting the *Battle of Anghiari*, Leonardo's father Piero died. Despite being a notary, Piero left no will, and thus his estate would have gone to only his legitimate sons—not to Leonardo.

LEAVING FLORENCE

In 1506, Leonardo again left Florence for Milan. The most proximate reason was to secure payment for the second version of his *Virgin of the Rocks*, which had been declared by an arbitrator as “*imperfetto*”—both incomplete and imperfect. “Specifically, the judgment was that there was not enough of Leonardo's hand in it, so he was required to come add his own finishing touches before payment would be made.” The Florentine authorities allowed Leonardo to leave for diplomatic reasons, believing he was going to Milan to maintain good relations with the French King Louis XII, in addition to securing his payment. But this was all a pretext, and he “heeded the summons to Milan because he wanted to go there,” having no desire to continue to complete with Michelangelo in Florence. Though he was supposed to return in three months, he did not. A curt back-and-forth ensued, but Leonardo would continue to stay in Milan.

FRANCESCO MELZI

“While in Milan in 1507, Leonardo met a fourteen-year-old named Francesco Melzi,” whom he would come to adopt, becoming a mentor, employer and teacher to him. “For the rest of Leonardo’s life, Francesco Melzi would be by his side,” working as a personal assistant, scribe and heir. Francesco never became a master painter, but he was an able artist. “[He] was also a loyal and caring companion to whom Leonardo could pass along his papers, his estate, his knowledge, and his wisdom.”

FLORENCE INTERLUDE: AN INHERITANCE BATTLE

An inheritance dispute brought Leonardo back to Florence in August 1507. Leonardo’s uncle Francesco da Vinci had died, leaving his estate to his nephew. This contradicted the understanding that Francesco’s property would go to Piero’s legitimate sons, who sued Leonardo for the estate. Even a letter from the king of France did not settle the matter. Eventually, Leonardo would be given use of the property, but after his death, it was given to his half-brothers. After eight months in Florence, Leonardo’s relations with the Milanese rulers became a bit strained, so he sent Salai to smooth things over and bring gifts. In April 1508, he had returned to Milan, where he would remain for the rest of his life.

MILAN’S DELIGHTFUL DIVERSIONS

Although he had a less-than-pleasant history in Florence that compelled him to leave, Leonardo primarily departed to Milan for its comparative intellectual diversity, since Florence was dominated by a love of the arts. In Milan, Charles d’Amboise, the French royal governor, “was dedicated to creating a court like that of the Sforzas, which included painters, entertainers, scientists, mathematicians, and engineers.” Milan also had a pageant culture that surpassed that of Florence. For d’Amboise’s palace, Leonardo had the chance to design a great hall for larger and more extravagant festivities, in addition to a “garden of delights,” filled with water contraptions and fountains. Neither was ever actually built, but Leonardo seems to have taken great joy in devising such engineering and artistic feats.

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CHAPTER TWENTY-SEVEN

ANATOMY, ROUND TWO

THE CENTENARIAN

At the hospital of Santa Maria Nuova in Florence in 1508, Leonardo met a man who claimed to be more than 100 years old. He would later dissect the man's body and would subsequently take detailed notes and make finely detailed drawings in his notebooks, starting with the old man's skin, muscles, then right arm and neck, torso, organs and ending in the liver. In his dissection, Leonardo attempted to discover the cause of death, coming to the conclusion that the man had died of arteriosclerosis—hardening of the arterial walls—using signs of poor circulation to draw his conclusion. This would have been the first record of such a diagnosis.

DISSECTIONS

Although dissections were controversial at the time, especially among the religious, Leonardo had no qualms. He compared his drawings to the dissections anatomy instructors would carry out for their students, boasting that his were far more detailed and useful. He also wrote down several odd tasks on his human anatomy to-do list, including investigating the woodpecker's tongue and the crocodile's jaw, illustrating the esoteric connections that he made in his mind between subjects. He had picked up several books on anatomy by this time, taking advantage of the revolution brought about by the printing press.

“But, true to form, Leonardo preferred learning from experiment rather than from established authority. His most important hands-on inquiries came during the winter of 1510-11, when he collaborated with Marcantonio della Torre, a twenty-nine-year-old anatomy professor at the University of Pavia.” Drawing from more than 20 dissections, Leonardo produced 240 drawings and at least 13,000 words. But Marcantonio would succumb to the plague in 1511, cutting short Leonardo’s and his collaboration.

ANALOGIES

Throughout his anatomical studies, Leonardo used analogies to explain the structures of the human body. He compared the circulatory system to the flow of the digestive, urinary and respiratory systems, drawing similarities between their branching out and the branching of plants and rivers. Another analogy reflected in his drawings, in which body parts were shown from multiple angles and layers and were sometimes exploded in view, Leonardo’s understanding of machines was used to analyze the movement and function of muscles. He also applied the casting technique he had used for Ludovico’s horse statue to map the cerebral ventricles of the brain.

MUSCLES AND BONES

“Leonardo began his studies of human muscles, as with most of his scientific work, to serve his art, but he was soon pursuing them out of pure curiosity.” Text on some of his drawings note how he intended to use his knowledge of anatomy to create more realistic paintings. But “[by] the time Leonardo got around to studying and drawing the human spine, he had been captivated by curiosity and the joy of research rather than merely the pursuit of practical painting knowledge.” This produced an extremely detailed study of the human spine and questions for future study.

LIPS AND SMILE

“Leonardo was especially interested in how the human brain and nervous system translate emotions into movements of the body. ... Of all these nerves and related muscles, the ones controlling the lips were the most important to Leonardo.” To ascertain the muscles responsible

for various facial expressions, he carried out partial dissections of faces. For his *Battle of Anghiari* drawings, he would even dissect a horse's face to see if similar muscles controlled their emotions. For his studies of nerves, Leonardo sought to distinguish which originate in the brain and which in the spine. Focusing on lips in particular, one page of his notebook shows a tantalizing hint of the smile in his famous *Mona Lisa*.

THE HEART

“Leonardo’s studies of the human heart, conducted as part of his overall anatomical and dissection work, were the most sustained and successful of his scientific endeavors.” Directly contradicting the second-century A.D. work of Galen, which had seen a rediscovery during the Renaissance, Leonardo concluded “that the heart, not the liver, was the center of the blood system. ‘All the veins and arteries arise from the heart,’ he wrote” in one of his many notebooks. He also mapped out how blood vessels narrow the farther away from the heart they are and was the first to note that the size of the branches of blood vessels and arteries diminish each time they split. Among his other discoveries were that the heart is a muscle, not a special kind of tissue, and that the heart has four ventricles, not two.

THE AORTIC VALVE

“Leonardo’s greatest achievement in his heart studies ... was his discovery of the way the aortic valve works.” Using his research on fluid dynamics to inform his study, he discovered that fluid drag contributes to the circular motion of blood in the heart. Liquid flowing through a channel or pipe is slowed down on the outside by friction, with the center being the least affected. In the heart, this kind of motion closes the valves as blood enters through the aorta. “The revolving blood beats against the sides of the three valves and closes them so that the blood cannot descend,” wrote Leonardo. This conclusion was only confirmed in the 1960s, which further demonstrated just how keen a scientist Leonardo was.

THE FETUS

“Leonardo’s anatomical studies culminated with his depiction of the beginning of life,” which produced the now-famous drawing of a fetus

in the womb. Although not completely accurate, the illustration is nevertheless striking in its combination of artistic beauty and scientific rigor. “Just as he had made an analogy between the branching of plants and rivers and blood vessels, so he noticed the similarities between the way plant seeds and human embryos develop.” In particular, he drew a connection between the funiculus, a stalk “that connects the seed to the wall of its ovule until the seed becomes ripe,” with the umbilical cord.

LOST IMPACT

Leonardo never published his studies on the human body, leaving yet another layer of mystery to his studies: If he never intended to share what he discovered, what explains the deep motivation behind his work?

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CHAPTER TWENTY-EIGHT

THE WORLD AND ITS WATERS

THE MICROCOSM AND THE MACROCOSM

At the same time he was studying the human body, Leonardo was studying the earth, drawing comparison between “the body of man and the body of the earth.” In a notebook now known as the Codex Leicester, Leonardo explored this microcosm-macrocosm relationship, with a goal to understand “the causes and effects that rule our cosmos, ranging from the mechanics of our muscles to the movement of the planets, from the flow in our arteries to that in the earth’s rivers.” Most importantly, Leonardo realized that the earth was changing and evolving and thus had a dynamic history.

“By the time he finished the Codex Leicester, he would discover that the comparison between the earth and the human body was not always useful. Instead, he came to fathom how nature had two traits that sometimes appeared to be in conflict: there was a unity to nature that resonated in its patterns and analogies, but there was also a wondrously infinite variety.”

WATER

The primary focus of the Codex Leicester is the movement of fluids, particularly water. Leonardo’s fascination with hydrodynamics can be seen in both his scientific and artistic endeavors, but the nature of his inquiries soon turned to more esoteric interests. “Water provided the perfect manifestation of Leonardo’s fascination with how shapes are

transformed when in motion.” At times, his fascination seemed to firmly cross the line into obsession, as when he listed 730 conclusions about water on eight pages or wrote down 67 words to describe the flow of water. Even still, he was able to tie his fixation to practical applications.

“While in Florence, he devised a pair of goggles for his dives in the Arno so he could study the water as it flowed past a weir.” He also threw corks into the river to measure relative speeds and measured how currents change by depth. “The primary tool he used, however, was simple observation, though his acute visual focus meant that he saw things the rest of us would miss.”

DIVERSIONS, EDDIES, WHIRLPOOLS, AND VORTEXES

“Leonardo had a keen interest in what happens when a flow of water is obstructed. The dynamics of water, he realized, are connected to the two proto-Newtonian ideas about motions that he embraced: impetus and percussion.” Impetus was essentially the idea of inertia, while percussion can be described as “what happens when a body in motion hits another object.” On one page of the Codex Leicester, Leonardo drew 14 “examples of what different obstacles do to the flow of water.” He then compared the forces that create swirls in water to those that create a hair curl, again illustrating how analogies dominated his thinking.

He “was especially interested in eddies that form when flowing water is deflected from its path. As his drawings show, the water flowing past an obstacle curves toward the area directly behind the obstacle, where there is less water, forming a vortex.” Most impressively, he “realized that waves do not actually involve water moving forward,” but rather an up-and-down motion.

REVISING THE ANALOGY

Leonardo came to revise the microcosm-macrocosm analogy, motivated primarily by his observations that water erupted in springs at the top of mountains and blood in the body goes up to the head, rather than just pooling at the lowest point. “Assuming that similar effects have similar causes, he began his quest to figure out what force

impels liquids to move upward to become mountain springs.” His initial explanations included the theory that water was heated up and then condensed at a higher altitude, an idea debunked by the existence of cold mountain springs. But on a page of the Codex Leicester from 1510, it is clear he had arrived at the modern concept of the water cycle: “The origin of the sea is contrary to the origin of the blood ... [because] all the rivers are caused solely by the water vapors raised up into the air.”

FLOODS AND FOSSILS

Leonardo understood the concept of erosion and then applied that knowledge to explain how two sides of a mountain valley could have the same layers of sedimentary rock. He then turned to fossils, wondering how creatures from the ocean could end up embedded in the high mountains. His conclusion was that “[from] time to time the bottom of the sea was raised, depositing these shells in layers.” Of particular interest to him were trace fossils, remnants of live animal activity, which debunked the commonly held idea that a biblical flood had washed up the remains of animals from the ocean. He even discovered how to tell the age of a shellfish by counting a pattern on its shell, as with tree rings or sheep horns.

ASTRONOMY

On one page of one of his notebooks, Leonardo wrote, “*Il sole nó si move*. The sun does not move.” Whether this was a sign that he was ahead of Copernicus and Galileo is unclear. “[But] he did come to the realization that the earth is only one of many cosmic bodies, and not necessarily the central one. ‘The earth is not in the center of the sun’s orbit nor at the center of the universe, but in the center of its companion elements, and united with them,’ he wrote.” Leonardo also correctly surmised that the moon emits no light of its own and that the Earth would similarly reflect light from the sun if viewed from the moon.

BLUE SKY

As many great men who would come after him, Leonardo was curious as to why the sky is blue, and he even arrived at something close to the truth: “The air takes the azure through the corpuscles of humidity,

which catch the luminous rays of the sun.” Using black pigment and then painting over it with a white wash, he was able to test this theory, proving that the blue would be most brilliant when black and white were juxtaposed.

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CHAPTER TWENTY-NINE

ROME

VILLA MELZI

In 1512, the French were losing their control of Milan, and by the end of the year, Maximilian (Massimiliano) Sforza—son of Ludovico—would reclaim the city. Leonardo’s French patron Charles d’Amboise had died in 1511, marking the beginning of a four-year search for a new patron. But “[for] most of 1512, he resided comfortably in the family home of his student and surrogate son, Francesco Melzi.” There, Leonardo dissected animals, finished his geological work for the Codex Leicester and gave architectural suggestions to his host family.

PORTRAITS OF LEONARDO

While residing at the Melzi house, Leonardo turned 60. One sketch from the time period shows an old man with a walking stick, “his left hand held up to his head as if in contemplation or perhaps feeling melancholy. His balding hair is wispy on top, though still curly. His beard flows down almost to his chest. His eye stares alertly, though with signs of fatigue.” We cannot be certain this old man is meant to be Leonardo, but it does match a drawing Francesco made around the same time and captioned “Leonardo Vinci.” The image of Leonardo as a wizened and almost sage-like old man is also present in other works: notably Raphael’s *School of Athens*. Another possible self-portrait is the so-called Turin portrait, a red-chalk drawing that shows a similar old man with a distinctive nose, flowing hair and beard.

TO ROME

In 1513, Giovanni de' Medici was elected to become Pope Leo X. With his brother Giuliano de' Medici, Leo established an intellectual court, and they would serve as willing patrons for Leonardo. In September of that year, Leonardo departed Milan for Rome, a city that held people familiar to Leonardo, such as architect-artists Donato Bramante and Antonio Pollaiuolo. At the time, Bramante was building a courtyard—designed by Pollaiuolo—connecting the Vatican to the papal summer palace, the Villa Belvedere.

It was in this modified villa that Leonardo was given living space—with windows and space for his expansive hobbies and a garden full of rare plants, which he studied, focusing on the spiralling arrangements of leaves. Using his position, he also helped his half-brother Giuliano da Vinci—a notary—resolve a small financial matter with the Church.

Despite his patrons' great love of painting, Leonardo did not start any new works during this time. He did, however, take on “the job of devising a way to drain the Pontine Marshes, fifty miles southeast of Rome, for Giuliano de' Medici, who had been assigned the task of reclaiming the land by his brother,” in addition to a new invention for minting coins with good edges.

Despite having these new projects to pull his focus, he primarily fixated on mirrors. “Over the years, Leonardo became increasingly interested in the mathematics involved in focusing a mirror, drawing scores of diagrams of light rays from different directions hitting a curved surface and showing the angles at which they would be reflected.” He would fill at least 20 pages of his notebooks on the topic of concave mirrors, especially very large ones—with the idea of using them as weapons.

At this time, Leonardo also displayed an uncharacteristically bad temperament, growing enraged, confused and almost paranoid about both a German assistant and a rival mirror-maker, whom Leonardo would complain about in rambling letters to his patron Giuliano.

In 1515, Giuliano was sent away from Rome and subsequently died of tuberculosis, at which time Leonardo was invited to go with Pope Leo

to Florence and Bologna. In Florence, he proposed designs for rejuvenating the city's architecture, much like Bramante was doing in Rome. "But Leonardo did not stay in Florence." Instead, he continued to Bologna, where he came into fateful contact with the new King of France Francis I.

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CHAPTER THIRTY

POINTING THE WAY

THE WORD BECOMES FLESH

Between 1506 and 1516, Leonardo wandered between Milan and Rome. During this time, he produced three paintings of a similar theme. “These include two sensuous paintings of Saint John the Baptist, one of them converted into a rendering of Bacchus by someone many years later, and a painting of an angel of the Annunciation that has been lost. They feature, as do their related drawings, a sweetly androgynous young man with an enigmatic aura, looking (or perhaps even leering) directly at the viewer and pointing a finger.” What sets these paintings apart is that the subject is looking at and directing their gestures directly to the viewer.

SAINT JOHN THE BAPTIST

“From sketches in his notebook, we know that Leonardo had already begun working on his portrait of Saint John the Baptist ... while in Milan in 1509.” But, as with many other works, he would continually tweak and add to this painting until the end of his life. “His focus was on the saint’s eyes, mouth, and gesture,” with the figure surrounded solely by darkness and his delicately curled hair serving as the only ornamentation. There is a hint of sensual tension in John’s smile, emphasized by his broad yet feminine torso, and his hand is very clearly depicted without great use of sfumato, making it seem “to pop out toward us and be more in focus.” Pointed toward the source of light, the hand perhaps alludes to John’s biblical role in paving the way for Jesus.

SAINT JOHN WITH THE ATTRIBUTES OF BACCHUS

“The other variation of this theme to emerge from Leonardo’s studio ... shows a full-length Saint John sitting on a dark rock formation with a sunny landscape of a mountain and a river to his right.” Although inventoried by Salai and the French royal art collection at Fontainebleau as depicting John, at some point in the late 1600s, it was listed as “Bacchus in a landscape,” suggesting that it was altered. A red-chalk drawing of this painting depicts a fully nude John, and “perhaps for reasons of religious and sexual propriety” it was ultimately modified to be Bacchus, the Roman god of wine and drunkenness. In this painting, John is pointing to the darkness, which may be an allusion to the death of Jesus.

ANGEL OF THE ANNUNCIATION AND ANGEL INCARNATE

Although *Angel of the Annunciation* is now lost, it is known through copies and student drawings as being almost entirely the same as *Saint John the Baptist*, except that it features an angel instead of John, and the pointing arms are reversed. “Then as now, Leonardo’s boy angels are feminine to the point of being androgynous; it is true of the angel in his early *Annunciation* and also of the one in *Virgin of the Rocks*. In this new *Annunciation*, the androgyny is more pronounced than ever. The angel has budding breasts, and his face is even more girlish.” Another sketch of this painting also exists, but it is with feminine nipples and a large phallus—an “extreme example of Leonardo’s dance around what he viewed as the ambiguous border between flesh and spirit as well as the one between feminine and masculine.”

A final drawing that features a subject mid-gesture is known as the *Pointing Lady*. “The black-chalk drawing is simple, but it encompasses many facets of Leonardo’s life and work: his love of plays and pageants, his feel for fantasy, his mastery of enigmatic smiles, his ability to make women come alive, and the twisting movement.” In keeping with this idea, the woman in the drawing is pointing, an important symbol in Leonardo’s later work. “In his last decade, Leonardo is mesmerized by that gesture, the signal of tidings borne by a mysterious guide who has come to show us the way. ... It is a profoundly expressive and poetic drawing by a man entering the twilight and still searching for guidance about the eternal mysteries that his science and his art have not, and cannot, explain.”

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CHAPTER THIRTY-ONE

THE *MONA LISA*

THE CULMINATION

Leonardo began working on the *Mona Lisa* in 1503 during his time in Florence after leaving Cesare Borgia. He would continue to work on it, adding small bits of paint here and there even until 1517. After his death, it was left behind, still in his studio. Although the work bears superficial similarities to *Ginevra de' Benci*, a portrait in three-quarter view done at the beginning of Leonardo's career, the *Mona Lisa* can be seen as exemplifying the culmination of his life's work, combining science, art and his myriad explorations into nature.

THE COMMISSION

The subject is Lisa del Giocondo, born in 1479 to the prominent but then-diminished Gherardini family. At 15 years old, she married Francesco del Giocondo, silk producer for the Medici, whose wife had died eight months earlier, leaving him with a two-year-old son. By the time she was 24, Lisa had given birth to two of Francesco's sons. It was at this point that Francesco commissioned Leonardo to paint a portrait of her. Despite Leonardo's known distaste for painting at this point, he may have taken on the commission partially out of obligation: His father Piero had been Francesco's longtime notary, and the Giocondo family had many ties to the church of Santissima Annunziata, where Leonardo had lived previously. As a relatively low-profile person, Lisa del Giocondo would also not have been in a position to demand a certain portrayal of herself, thus affording Leonardo far more creative liberty than other portraits typically allowed.

BUT IS IT REALLY LISA?

Vasari, who knew Lisa and Francesco's children, makes the straightforward claim that the painting is indeed of Lisa del Giocondo. But Antonio de Beatis, secretary to Cardinal Luigi of Aragon, on visiting Leonardo's studio, wrote of seeing a portrait of "a certain Florentine lady ... done from life at the instigation of the late Giuliano de' Medici." Adding a layer of mystery to the identity of the woman in the painting is the fact that de Beatis suggests a relation to Giuliano. The biographer Lomazzo, writing in the 1580s, also mentioned "the portrait of La Gioconda and *Mona Lisa*," suggesting the existence of two works, rather than one. Yet, as discovered in 2005, Agostino Vespucci made a note in the margin of an edition of Cicero in 1503 that Leonardo was working on "the head of Lisa del Giocondo," which seems to definitively prove her identity.

THE PAINTING

The portrait is on a center cut of a trunk of poplar, with a lead white primer coat rather than a more typical mix of gesso, chalk and white pigment. "That undercoat, he knew, would be better at reflecting back the light that made it through his fine layers of translucent glazes and thereby enhance the impression of depth, luminosity, and volume." Light is thus able to reach to the undercoat through the thin layers of paint. Leonardo also used glazes with a small proportion of pigment mixed into the oil. "For the shadows on Lisa's face, he pioneered the use of an iron and manganese mix to create a pigment that was burnt umber in color and absorbed oil well." He applied up to 30 layers of paint slowly over time in an irregular way, which created a more natural-looking texture.

In the famous painting, Lisa is in motion, as the subjects of Leonardo's best works always are. "Her torso twists slightly as her head rotates to look and smile directly at us." An unused underdrawing suggests he "initially drew her left hand grasping the chair arm as if she were about to rise, but then thought better of it."

As always, the way Leonardo played with optics and light is important in this work, as there are two subtle oddities about the light source, which shines from high up and slightly to the left in the *Mona Lisa*:

First, “the loggia on which she is sitting is covered,” meaning that the light should be coming from behind, yet it is shining on her from the front; second, the pupil facing the light is larger than the other, rather than smaller, as we might expect based on the way that pupils dilate. “Also a bit puzzling is the issue of Lisa’s eyebrows, or lack thereof.” Despite Vasari’s effusive praise for how well they were depicted—her eyebrows seem to have been lost when the painting was cleaned, as they were painted atop dry paint.

Putting tiny spirals and geometric shapes into her dress’s folds, Leonardo put an obsessive level of detail into Lisa’s clothing—an unsurprising fact, considering that Lisa was the wife of a silk producer. He even painted clothing that he would later cover up with another layer of paint, creating an intense level of depth and detail. The veil covering her hair is a razor-thin layer of glaze that sits on top of the landscape with a delicate transparency, adding a blurred edge to everything it touches.

The landscape of the portrait is seen from a bird’s-eye view, with a small bridge being the only manmade feature in the otherwise nature-dominated scene. “The landscape shows the living and breathing and pulsing body of the earth: its veins as rivers, its roads as tendons, its rocks as bones. More than being merely the backdrop for Lisa, the earth flows into her and becomes a part of her.”

THE EYES AND THE SMILE

As seen in other works of Leonardo’s, Lisa’s eyes seem to follow the viewer, no matter their angle. This can be explained in part by the fact that “in the three-dimensional real world, shadows and light on a face shift as our vantage changes, but in a two-dimensional portrait this is not the case. Consequently, we have the perception that eyes staring straight out are looking at us, even if we are not directly in front of the painting.”

Though her eyes remain remarkable in their ostensible motion, her smile is still the most historically captivating element in the painting. While he was creating the masterpiece, Leonardo was spending great amounts of time in the hospital of Santa Maria Nuova, engaging in his anatomical studies. Part of his research was conducted to better

understand the muscles of the face and how they controlled the shape of the lips. In the *Mona Lisa*, we can see the fruits of his efforts.

Add to this the fact that he painted the shadows around her mouth in such a way that the corners appear more upturned than they are only when the viewer looks elsewhere; look directly at her, and her smile seems to disappear. The blurriness of things seen through the periphery was something Leonardo discovered through his study of optics and the eye, applied here to great effect.

OTHER VERSIONS

Leonardo's students were also making versions at the same time as he was drawing the master work. One version was cleaned and restored in 2012, showing bright colors and features that Leonardo's lacks. But his is so beloved, even in its yellowed and darkened state, that there are no plans to do any such restoration.

FOR THE AGES

"The *Mona Lisa* became the most famous painting in the world not just due to hype and happenstance but because viewers were able to feel an emotional engagement with her. She provokes a complex series of psychological reactions, which she herself seems to exhibit as well. Most miraculously, she seems aware—conscious—both of us and of herself." As Leonardo's project for the final 16 years of his life, "it became more than a portrait of an individual. It became universal, a distillation of his accumulated wisdom about the outward manifestations of our inner lives and about the connections between ourselves and our world."

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CHAPTER THIRTY-TWO

FRANCE

FINAL JOURNEY

In December 1515, Leonardo met Francis I, the new king of France, then only 21 years old. Earlier that year, he had succeeded his father-in-law Louis XII, who had been a great fan of Leonardo. Even after their meeting in Bologna, Francis continued to recruit Leonardo, encouraged by his mother, Louise de Savoie, whose sister was married to Giuliano de' Medici. After Giuliano died, Leonardo finally relented and went to join the court of Francis I. "Along the way, he and his traveling party stopped in Milan. Salai decided to stay there" and would only visit Leonardo occasionally, preferring instead the vineyard just outside of Milan that Ludovico had given Leonardo.

FRANCIS I

In sharp contrast to Leonardo's earlier patrons, Ludovico Sforza and Cesare Borgia, Francis I was a decent man and a reasonable ruler. For instance, after capturing Milan, he allowed Duke Maximilian Sforza to be a part of his court. "Through his cultured mother, Louise de Savoie, and his bevy of dedicated and accomplished tutors, Francis was inculcated with a love of the Italian Renaissance," and he had dreams of bringing it to France. Like Leonardo, he was a polymath with interest in the classics, art, geography, history and languages. He would prove to be a perfect match for Leonardo, content to draw from Leonardo's vast knowledge and never pressuring him to complete any of his works. In fact, there were few days of the year that Francis and Leonardo even parted.

As elsewhere, Leonardo put on elaborate pageants for Francis, some of which included fake artillery shooting air-inflated balls and a new staging of *Paradiso* by Bernardo Bellincioni, “with players costumed as each of the seven known planets and the mechanical marvel of an egg-shaped orb opening up to reveal paradise.”

THE DE BEATIS VISIT

In October 1517, Cardinal Luigi of Aragon and his secretary Antonio de Beatis visited Leonardo in Amboise. De Beatis recorded the visit, describing Leonardo as “a greybeard of more than seventy years,” who showed his guests three paintings: “One of a certain Florentine lady, done from life at the instigation of the late Giuliano de’ Medici, the second ... of the youthful Saint John the Baptist, and a third of the Madonna with the Child placed on the lap of Saint Anne, all of the highest perfection.” Interestingly, he reported that Leonardo’s right hand had been paralyzed and that his assistant Melzi therefore made small adjustments to paintings that he wasn’t able to; this report is puzzling, as Leonardo was left-handed.

ROMORANTIN

“Rather than commissioning a big piece of public art, the king offered Leonardo an ideal assignment for the culmination of his career: designing a new town and palace complex for the royal court at the village of Romorantin.” From late 1517 to January 1518, Leonardo accompanied the king to the village, sketching up ideas. “The plan was for an idyllic palace rather than a fortress-like castle,” but always with water pageants and outdoor spectacles in mind. He expanded his plans to the whole region, devising a system of water canals connecting the Sauldre to the Loire and Saône rivers. But the project was abandoned in 1519, the year Leonardo died.

THE DELUGE DRAWINGS

“Leonardo’s interest in the art and science of movement, and in particular the flow and swirl of water and wind, climaxed in a series of turbulent drawings that he made during his final years in France.” There are 16 drawings still extant, all of which make it hard not to draw connections between the surging whirlpools and Leonardo’s own state

of mind as he neared the end of his life. “The pages contain framing lines, and the back side of each is blank, signaling that they were drawn for display, or perhaps as artistic accompaniments to a reading of an apocalyptic tale, not just as scientific illustrations in a notebook.” Accompanying the drawings are more than 2,000 words describing how to properly represent the powerful emotionality of a flood; the text also includes passages of both words and pictures that paint a scene of doomed people facing the violent and raw force of an impending deluge.

THE END

On what may have been one of the final pages he ever wrote in his notebook, Leonardo drew four right triangles, trying to work out how to create right triangles of different dimensions with equal areas. “Then abruptly, almost at the end of the page, he breaks off his writing with an ‘et cetera’ ... followed by a line, written in the same meticulous mirror script as the previous lines of his analysis, explaining why he is putting down his pen. ... Because the soup is getting cold.”

“On April 23, 1519, eight days after his sixty-seventh birthday, Leonardo had his last will and testament drawn up by a notary in Amboise, witnessed, and signed.” He specified his funeral wishes, including 60 candles carried by 60 poor men, who would be paid for their service. He also left a cloak and two ducats to his servant Mathurine, named Melzi the executor of his will and primary heir, and left his water rights and half of the vineyard Salai had been living on to Battista de Vilanis—a new young companion.

On May 2, 1519, Leonardo died and was later buried in the church of the Château d’Amboise. Vasari tells a story, probably embellished, of King Francis I rushing to Leonardo’s deathbed as the priest has just completed his last rites. Whether or not Francis was actually there, the moment became a trope in art, most famously as the subject of a painting by Jean-Auguste-Dominique Ingres.

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CHAPTER THIRTY-THREE

CONCLUSION

GENIUS

“What made Leonardo a genius, what set him apart from people who are merely extraordinarily smart, was creativity, the ability to apply imagination to intellect. His facility for combining observation with fantasy allowed him, like other creative geniuses, to make unexpected leaps that related things seen to things unseen.”

“Leonardo’s brilliance spanned multiple disciplines, which gave him a profound feel for nature’s patterns and crosscurrents. His curiosity impelled him to become among the handful of people in history who tried to know all there was to know about everything that could be known.” Isaacson concludes, “Leonardo was a genius, but more: he was the epitome of the universal mind, one who sought to understand all of creation, including how we fit into it.”

LEONARDO

LEARNING FROM

“Be curious, relentlessly curious.”

“Seek knowledge for its own sake.”

“Retain a childlike sense of wonder.”

“Observe.”

“Start with the details.”

“See things unseen.”

“Go down rabbit holes.”

“Get distracted.”

“Respect facts.”

“Procrastinate.”

“Let the perfect be the enemy of the good.”

“Think visually.”

“Avoid silos.”

“Let your reach exceed your grasp.”

“Indulge fantasy.”

“Create for yourself, not just for patrons.”

“Collaborate.”

“Make lists.”

“Take notes, on paper.”

“Be open to mystery.”

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