LEONARDO AND HIS WORLD

Everything seemed possible. Artists were mathematicians. Architects built astonishing structures. Thinkers of the time mastered ancient texts—once all but forgotten—on mathematics, engineering, astronomy, and medicine and made their own amazing discoveries. A new humanism, inspired by classical antiquity, appeared in the arts and sciences. With this celebration of intellectual prowess and physical beauty came a passionate belief in humanity's capacity for improvement and for bending nature to its will. This was the Renaissance—a rebirth of the intellectual drive and innovative spirit of ancient Greece and Rome. Its icon is Leonardo da Vinci. A man of little formal education but unbounded intellectual gifts, he was equally a scientist, an engineer, an anatomist, a creator of spectacles, and an artist.

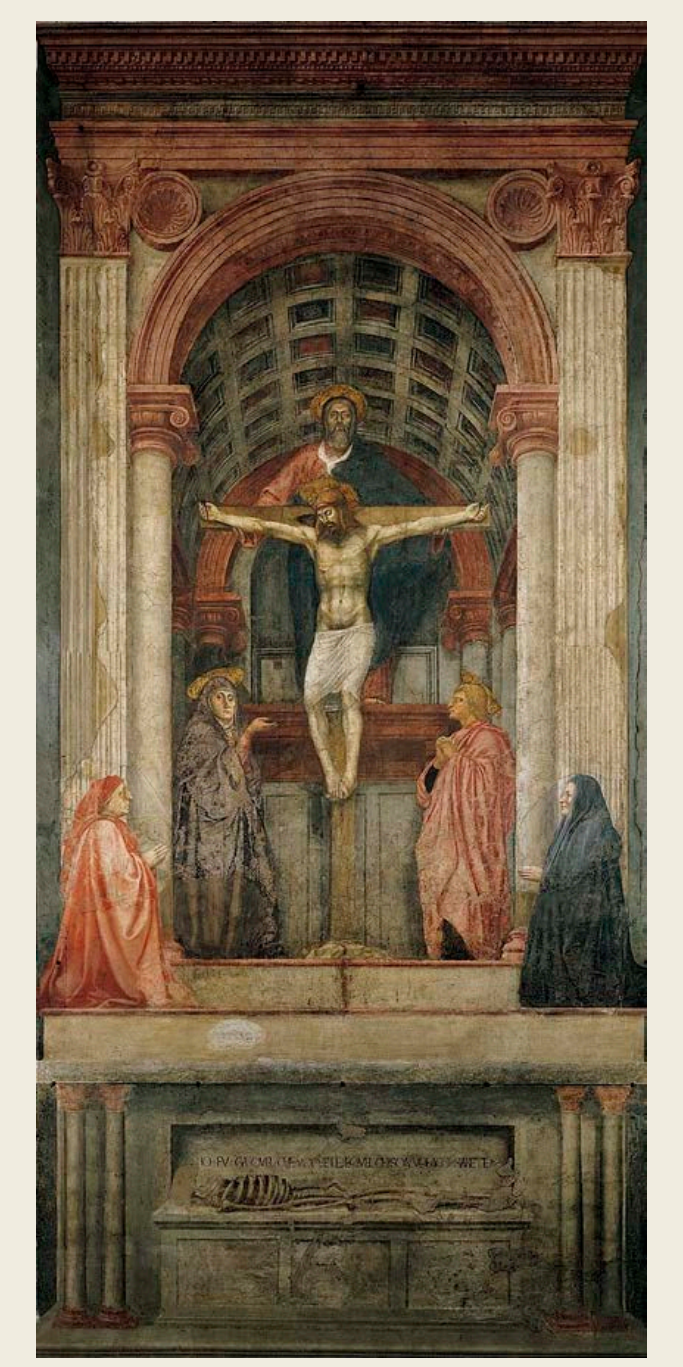
1400: Previously regarded as mere craftsmen, artists are now recognizing the intellectual, theoretical, even scientific nature of their work. Cennino Cennini writes a book on painting, *Il libro dell'arte* (The book of art), devising a color system based on the ideas of the ancient Greek philosopher Aristotle.

1405: Jacopo da Scarperia completes his translation of the work of the ancient Greek mathematician and astronomer Ptolemy, triggering scientific inquiry that ultimately leads Copernicus and Galileo to theories of a sun-centered universe.

1420–36: Applying principles of Roman architecture, Filippo Brunelleschi designs a massive dome for the cathedral of Santa Maria del Fiore in Florence—the largest dome built since ancient times—requiring no scaffolding, buttresses, or other supports.

Santa Maria del Fiore, Florence

1420s–30s: Brunelleschi rediscovers the mathematical principles of perspective, making possible spectacular illusions of space and depth. Masaccio is the first painter to successfully use this mathematical approach. In 1435, Leon Battista Alberti writes a treatise on painting, in which he develops mathematical theories about optics and perspective.


Masaccio, *The Holy Trinity with the Virgin, Saint John, and Donors*, c. 1425–27, fresco, church of Santa Maria Novella, Florence

1440s: Public libraries open in Rome and Florence, making the knowledge contained in thousands of manuscripts available to more people.

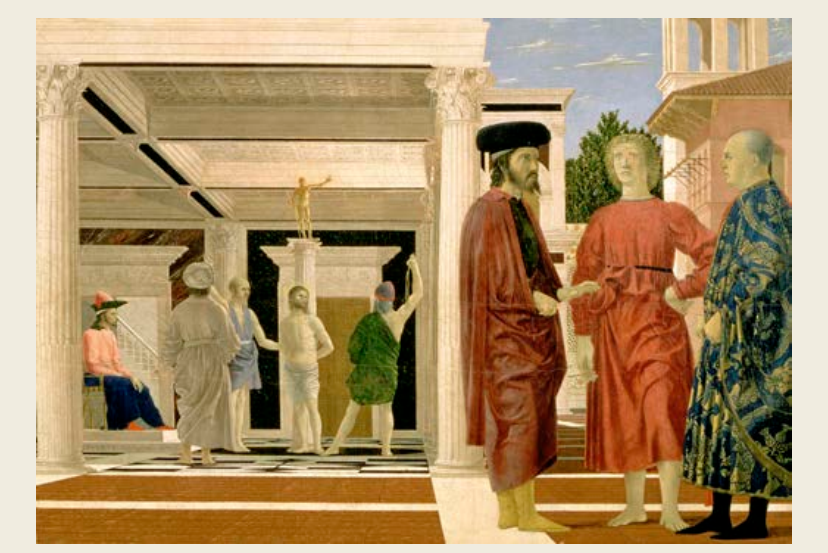
1440s–50s: Italian painters begin to adopt the slow-drying, semitranslucent oil paints used in Northern Europe. This allows them to work more slowly and methodically and to experiment with new ways of depicting the world around them.

1448: Johann Gutenberg's invention of movable type brings an explosion of knowledge—akin to that set off by the Internet today—as printing competes with hand-copying and more books are available at lower cost to the 15 or 20 percent of Europeans who can read at this time.

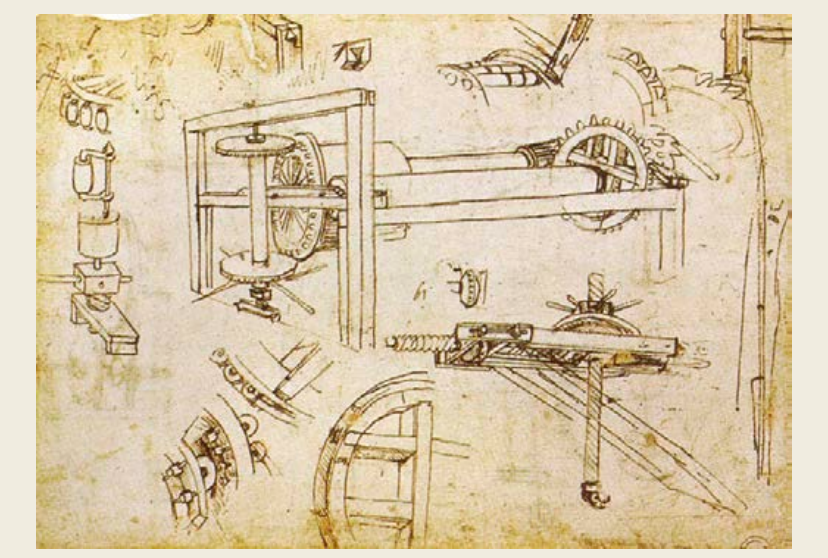
1452: Leonardo is born near the town of Vinci, to an unmarried couple; he is raised mainly by his grandparents and uncle. His humble origins limit his formal education, sparing him the intellectual constraints of academia.

1453: The Ottoman Turks conquer Constantinople (modern Istanbul), the capital of the Eastern Roman Empire. Intellectuals seeking refuge at the universities and courts of Italy bring with them ancient Greek manuscripts and scientific knowledge.

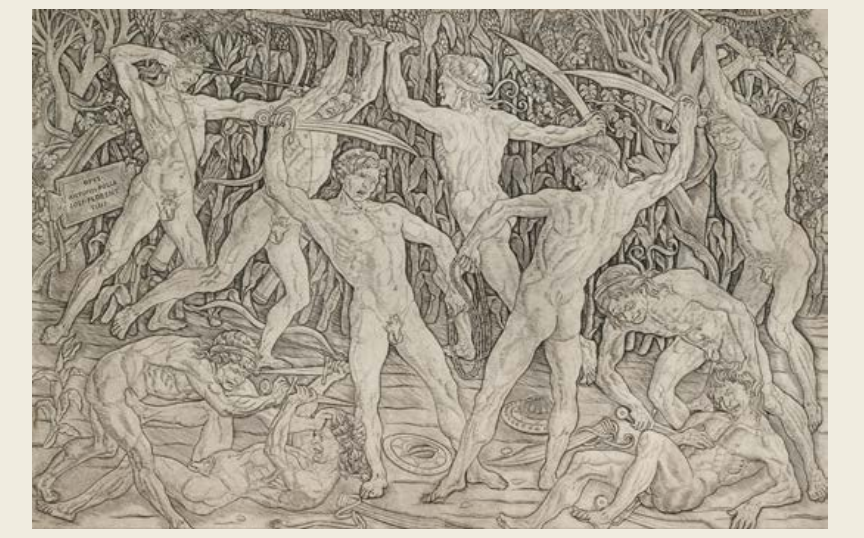
1450s: The artist and mathematician Piero della Francesca writes treatises on arithmetic, algebra, and geometry and applies mathematical ideas to his paintings.


Piero della Francesca, *Flagellation of Christ*, c. 1455–60, oil and tempera on panel, Galleria Nazionale delle Marche, Urbino

1469: Leonardo moves to Florence and apprentices himself to the artist Andrea del Verrocchio. He sketches the machines designed by Brunelleschi for building the cathedral dome in Florence. He will reference these studies throughout his life, in machines of his own invention.


Leonardo da Vinci, *Bridge crane (liftable by big screw)*, c. 1480, Atlantic Codex (Codex Atlanticus), folio 1083v, Biblioteca Ambrosiana, Milan

1470: Antonio del Pollaiuolo's paintings and engravings show an unprecedented knowledge of human anatomy, suggesting that the artist dissected human bodies.

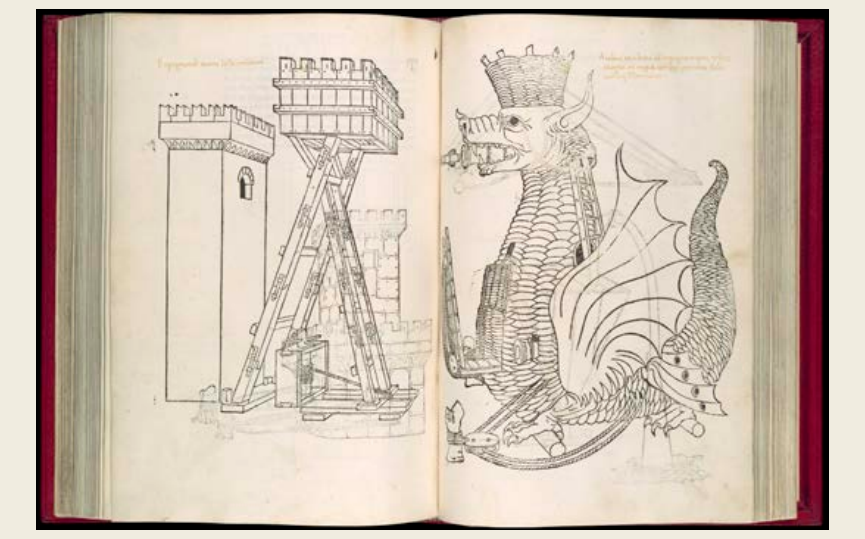

Antonio Pollaiuolo, *Battle of the Nudes*, c. 1470, engraving, Minneapolis Institute of Arts, bequest of Herschel V. Jones P.68.246

1470s–80s: Published Latin translations of ancient Greek manuscripts on the natural world, warfare, and mathematics become widely available, including Euclid's *Elements* and also a medical encyclopedia by the medieval Persian physician and scholar Avicenna.

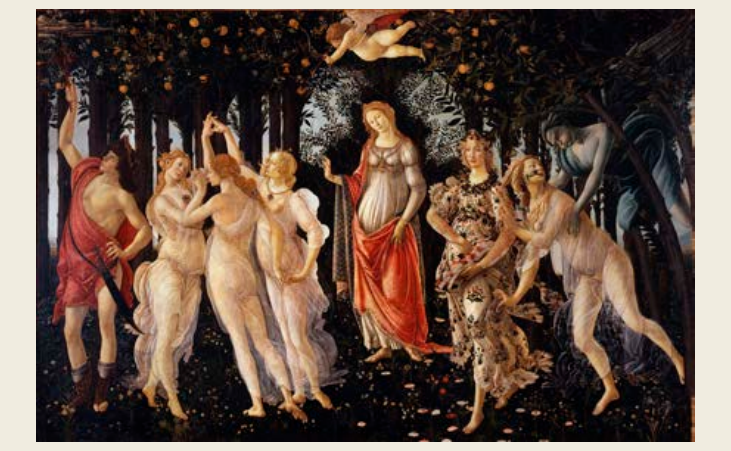
Euclid's *Elements*, Latin edition of 1482, printed in Venice by Erhard Ratdolt, Beinecke Rare Book and Manuscript Library, Yale University

1478: Leonardo leaves Verrocchio's workshop, becoming an independent painter in Florence. He begins making notes and sketches on engineering, hydraulics, and other subjects.

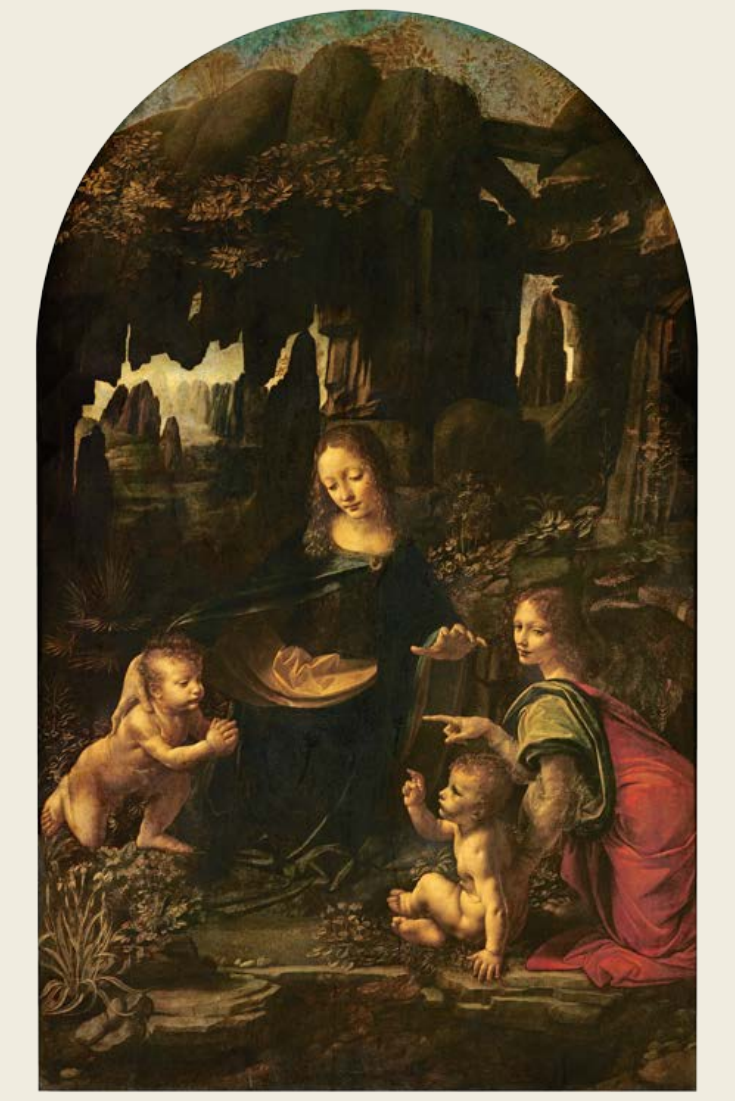
1483: Roberto Valturio's manuscript of 1460 on the military arts is printed in Italian. Fascinated by the accompanying illustrations, Leonardo applies them to his own ideas for machines of war. His inventiveness in military matters is clear from his letter, written around this time, seeking employment at the court of Ludovico Sforza, ruler of Milan, in which he describes his ideas for bridges, cannons, and armored cars and his practical knowledge of hydraulics and architecture.


Matteo de' Pasti, illustrations for Roberto Valturio's *De re militari*, 1472, Metropolitan Museum of Art

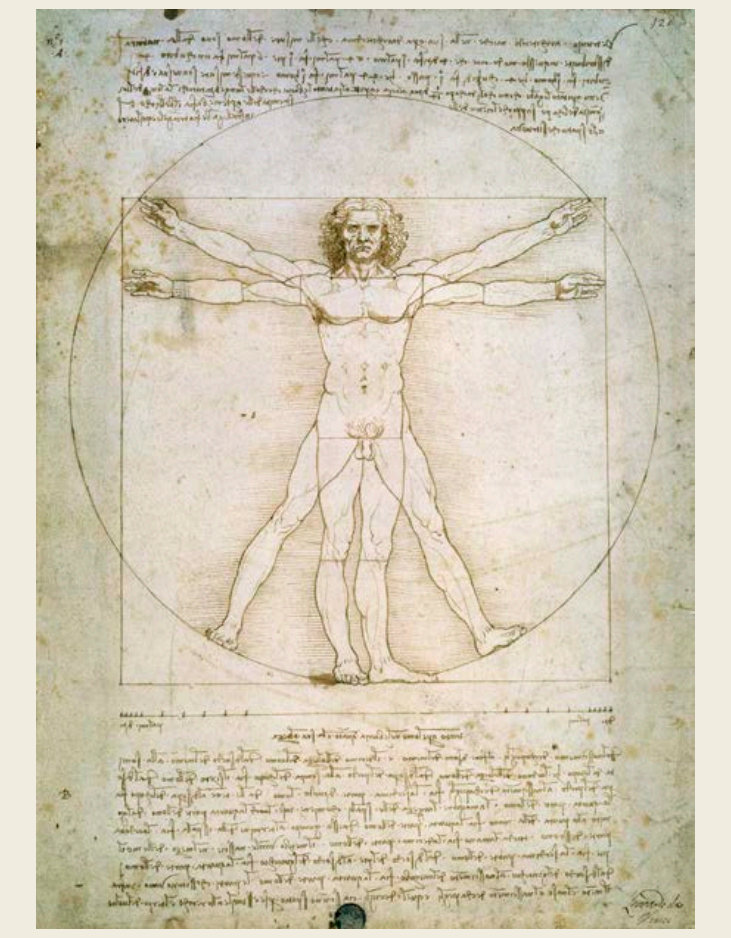
1480s: Sandro Botticelli, apprenticed like Leonardo to Andrea del Verrocchio, emerges as a preeminent painter in Florence. Leonardo later writes warmly of Botticelli but criticizes his inattention to perspective and landscapes.


Sandro Botticelli, *Primavera* (Spring), c. 1482, tempera on panel, Uffizi Gallery, Florence

1483–86: Leonardo paints *Madonna of the Rocks* for the Brotherhood of the Immaculate Conception in Milan. The accurate depiction of weathered, striated rocks and spring plants attests to his keen interest in the natural world and the forces that shape it.


Leonardo da Vinci, *Madonna of the Rocks*, c. 1483–86, oil on panel (transferred to canvas), Louvre, Paris

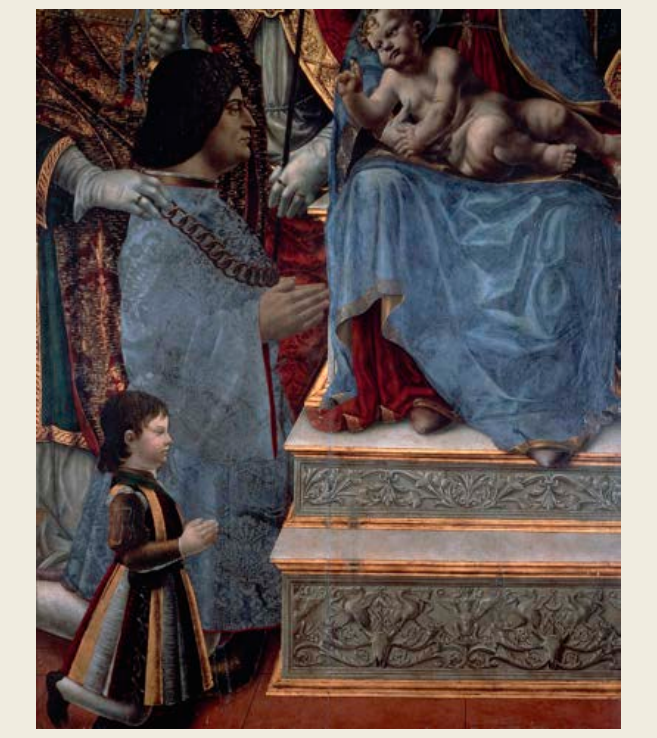
1487–92: Leonardo begins his anatomical studies and in 1492 draws his famous Vitruvian Man, based on ideas of the ancient Roman architect Vitruvius (c. 80–15 BCE), whose treatise *De architectura* was printed in Italy in 1486. Relating anatomy to architecture, the drawing illustrates mathematical relationships among various parts of the body.


Leonardo da Vinci, *The proportions of the human figure, after Vitruvius*, c. 1492, pen and ink on paper, Gallerie dell'Accademia, Venice

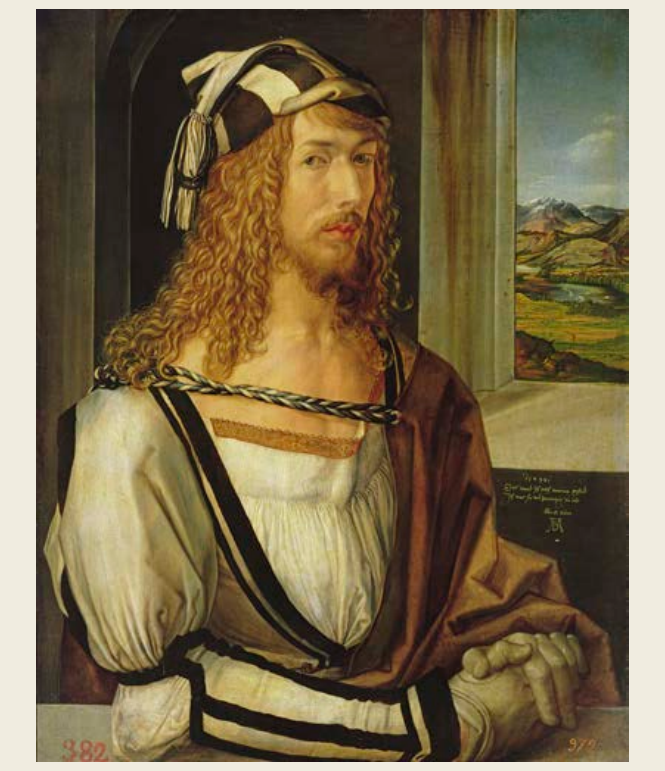
1492: Christopher Columbus sets sail looking for a westward route to Asia but instead encounters the Caribbean, awakening Europe to the existence of vast continents to its west.

1494: Leonardo's great patron Ludovico Sforza is named Duke of Milan after his nephew dies in mysterious circumstances.

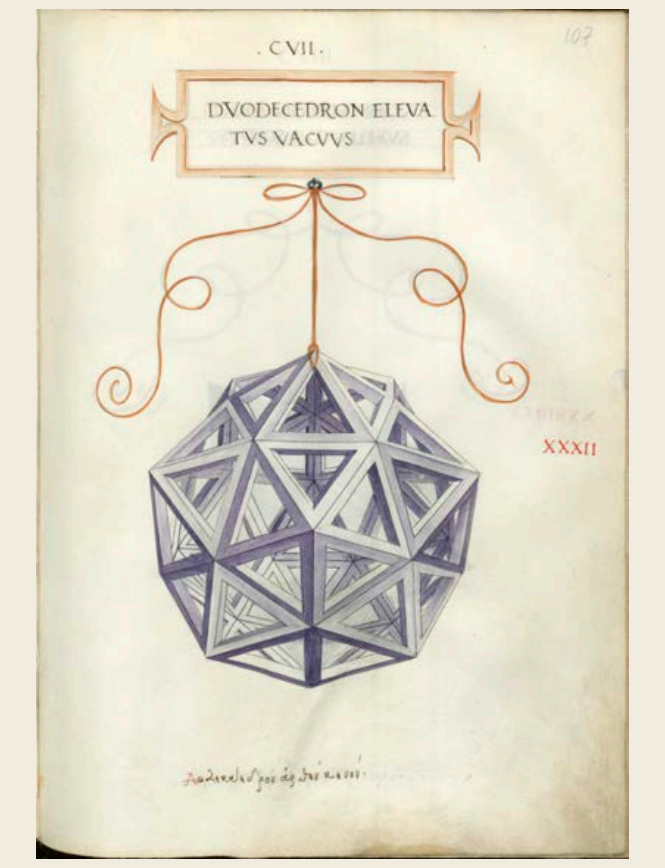
Even as he scoffs at those who keep their noses buried in books, stating that book knowledge is no substitute for direct experience of nature, Leonardo at age 42 teaches himself Latin so that he can read scientific and mathematical treatises.


Master of the Sforza Altarpiece, detail of Ludovico il Moro and his son Cesare from *Madonna and Child Enthroned with the Doctors of the Church and the Family of Ludovico il Moro*, 1494, tempera on panel, Pinacoteca di Brera, Milan

At age 26, the German artist Albrecht Dürer, known throughout Europe for his innovative prints, travels to Venice and meets the artist Giovanni Bellini and Bellini's students Titian and Giorgione. Dürer is instrumental in bringing principles of Italian Renaissance painting to Northern Europe.


Albrecht Dürer, *Self-Portrait with Gloves*, 1498, oil on panel, Prado, Madrid

1497: Leonardo collaborates with the great mathematician Luca Pacioli on the treatise *On the Divine Proportion*, contributing mathematical insights and illustrations. They present a lavishly illustrated manuscript to their patron Ludovico Sforza. The book is published in 1509.

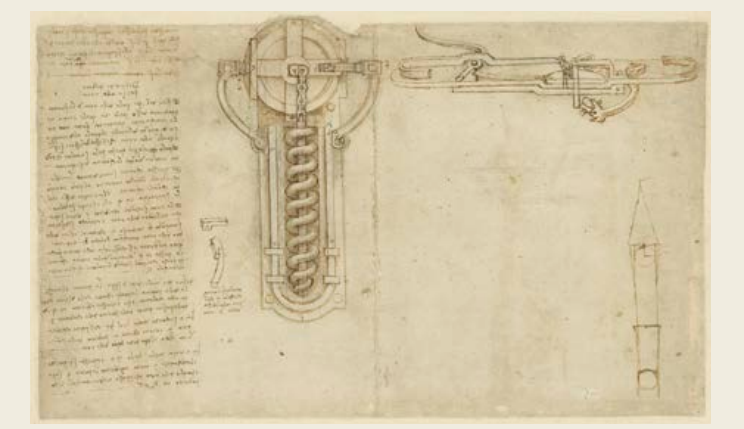

Attributed to Leonardo da Vinci, *Duodecedron elevatus vacuus* (Elevated dodecahedron with open faces), from *De divina proportione* (On the divine proportion), by Luca Pacioli, plate XXXII, folio 107r, Biblioteca Ambrosiana, Milan

1497–98: The Portuguese explorer Vasco da Gama sails around Africa to reach India, opening a sea route to the East.

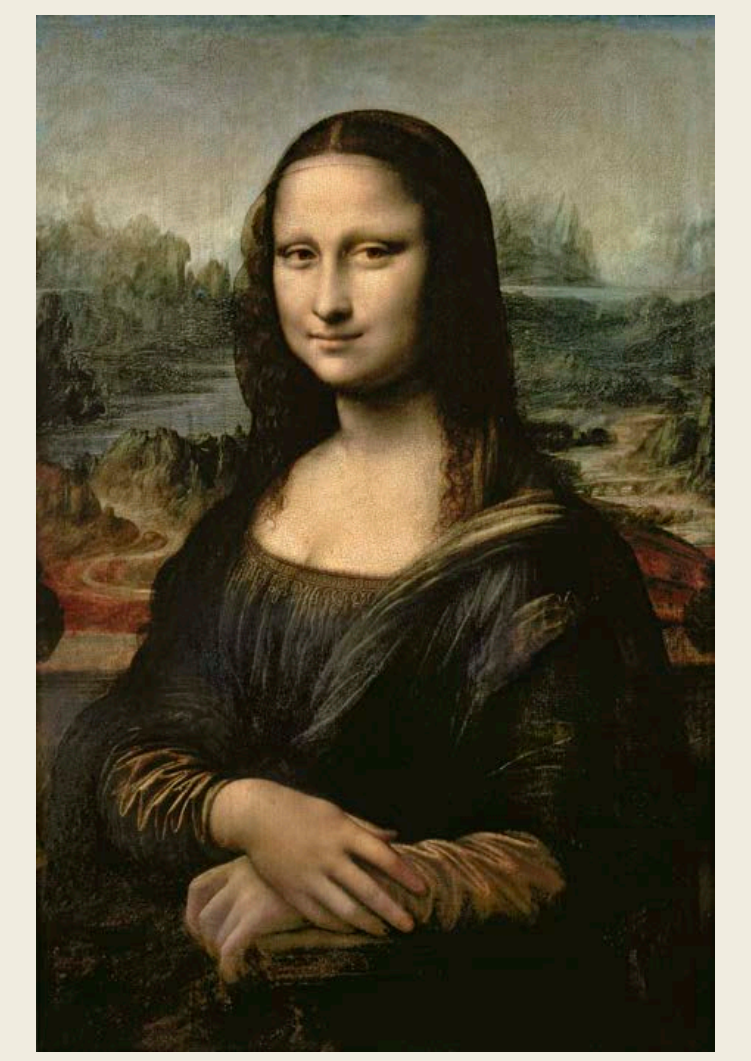
1498: Leonardo climbs Monte Rosa, Europe's second-highest mountain. The world literally comes into focus as he views the Rhine, Rhone, Danube, and Po rivers and sees how the earth and its waterways interrelate. Later, he makes extraordinarily accurate maps of Italian landscapes.

Leonardo da Vinci, *Map of the Valdichiana*, c. 1503–4, pen and ink with watercolor and gouache over chalk, Royal Collection Trust

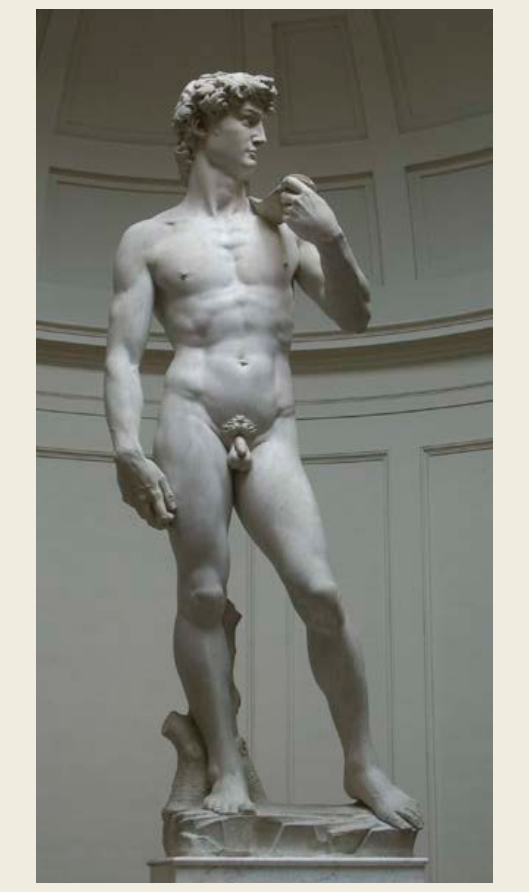
1499–1500: King Louis XII of France invades Milan, unseating Ludovico Sforza and ending Sforza rule. Adrift without his patron, Leonardo travels to Venice and then returns to Florence in 1500. He takes artistic commissions and continues his scientific studies and experiments. He designs a musket and wheel-lock mechanism, a working model of which will be made in 1515 by a German watchmaker in Nuremberg.


Leonardo da Vinci, *Two models of a device to turn on charge of a firearm*, 1500, Atlantic Codex (Codex Atlanticus), folio 158r, Biblioteca Ambrosiana, Milan

1503–6: Leonardo paints the *Mona Lisa*. The subject is Lisa del Giocondo, the wife of a wealthy silk merchant.


Leonardo da Vinci, *Mona Lisa*, c. 1503–6, oil on panel, Louvre, Paris

1504: Michelangelo completes his *David* sculpture in Florence.


Michelangelo, *David*, 1504, marble, Accademia di Belle Arti, Florence

1505: Leonardo produces a painstakingly illustrated treatise on bird flight.

Leonardo da Vinci, Codex on the Flight of Birds, 1505, folio 8r (detail), Biblioteca Reale, Turin

1507–12: Leonardo returns to Milan under French patronage. He provides engineering services, creates court spectacles, and develops architectural plans. He enjoys greater freedom to pursue his scientific inquiries and is even given a section of a canal to use for his experiments. He starts writing the notes that will later be assembled into the Codex Leicester and also manuscripts detailing investigations of botany, geology, meteorology, and human anatomy.

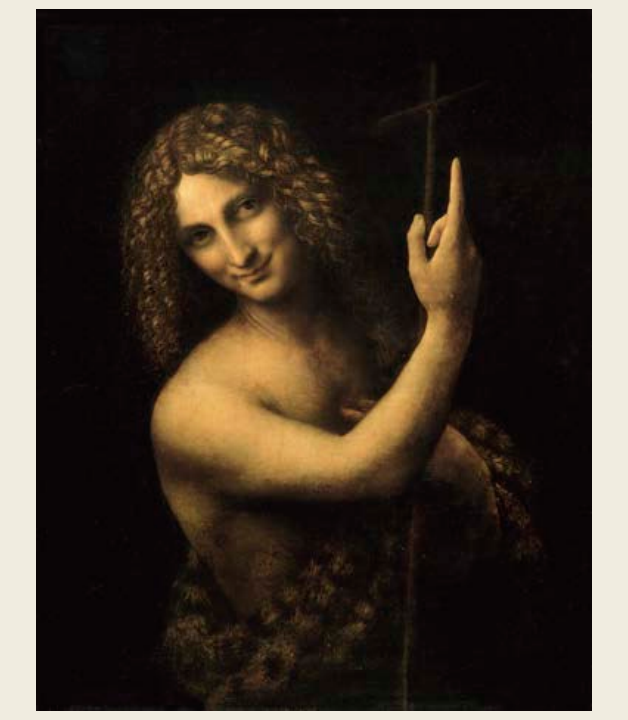
1509: Henry VIII is crowned king of England.

An earthquake and tsunami devastate Constantinople. Such phenomena are intensely interesting to Leonardo (though this event is not mentioned in his surviving papers).

1513: Following the fall of Milan's French government, Leonardo leaves for Rome, but not before completing a manuscript on the human heart. In Rome, the aging artist finds himself in the company of up-and-coming young artists such as Michelangelo and Raphael. He turns to further study of nature and the invention of machines, including ones for fabricating rope and striking coins.

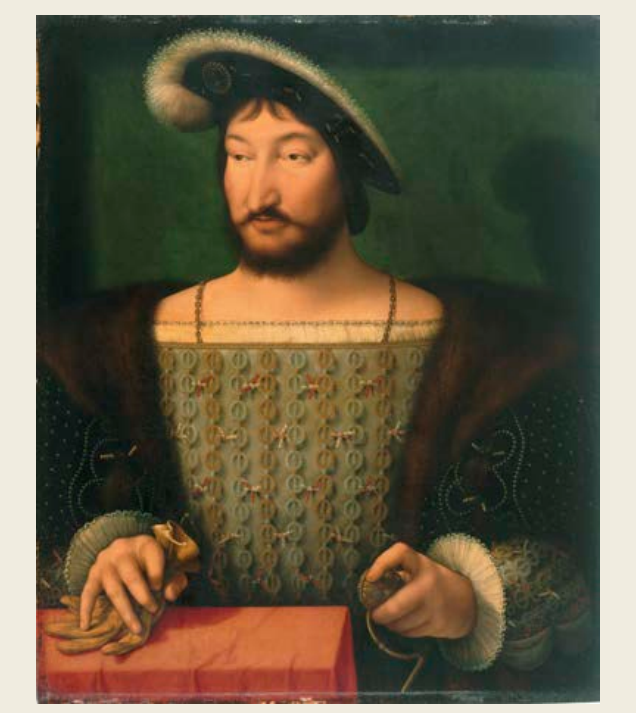
Leonardo da Vinci, *The bones and muscle of the arm*, c. 1510, pen and ink with wash over black chalk on paper, Royal Collection Trust

1513–16: Leonardo produces his last painting—an image of Saint John the Baptist.


Leonardo da Vinci, *Saint John the Baptist*, 1513–16, oil on canvas, Louvre, Paris

1515: Francis I is crowned king of France and retakes parts of Italy, including Milan. According to later sources, Leonardo devises a mechanical lion that walks toward the king and opens its chest to offer a spray of lilies.

1516: Leonardo becomes interested in creating curved mirrors, believing the sun's reflected rays can be a heat source. Unfortunately, disagreements with the two men tasked with constructing the mirrors kill the project.


Joos van Cleve, *Portrait of Francis I, King of France*, c. 1532–33, oil on panel, Philadelphia Museum of Art

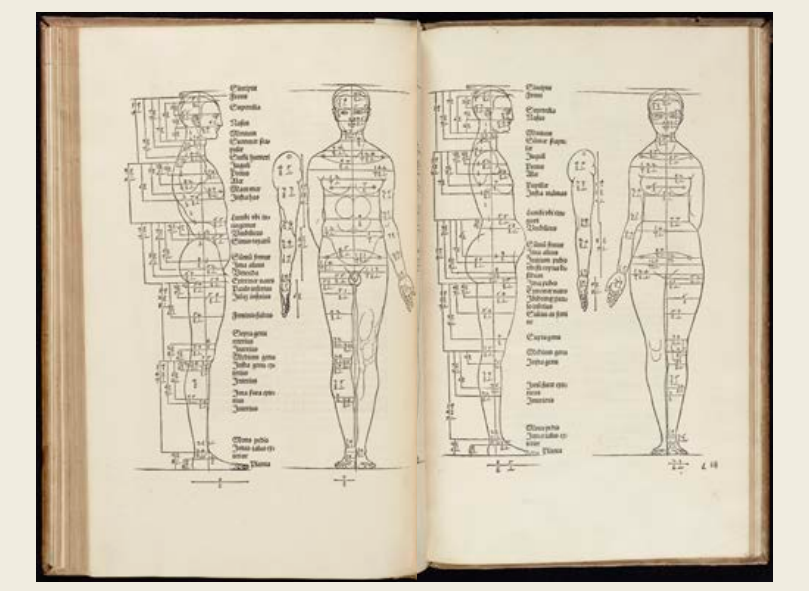
1517: Invited by Francis I, who reveres him, Leonardo moves to France.

Girolamo Fracastoro, of Verona, echoes Leonardo's theory that fossils are the remains of living things deposited over time in a dynamic and changing earth—not, as theologians argued, the result of the biblical flood.

Martin Luther posts his Ninety-Five Theses, igniting the Protestant Reformation.

1519: Leonardo dies in France at the age of 67.

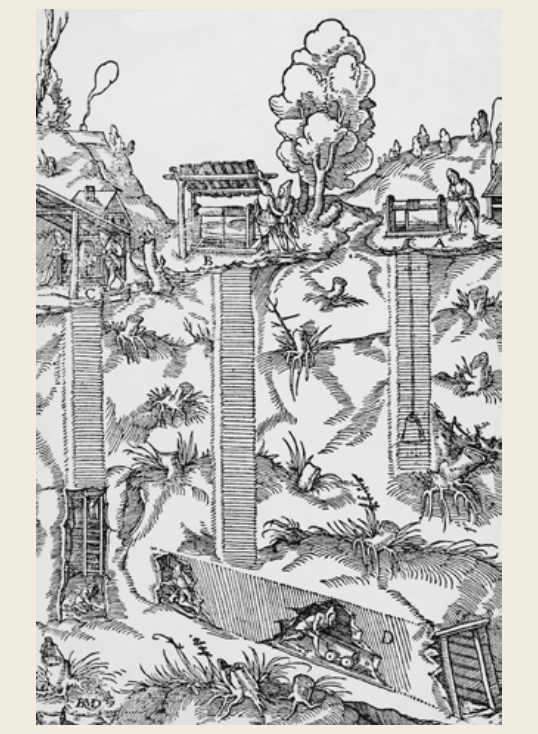
1525: Albrecht Dürer publishes two great treatises on human proportions, based on Italian ideas of using geometry to create the illusion of three-dimensional space.


Albrecht Dürer, *Hierinn sind begriffen vier Bücher von menschlicher Proportion* (Four books on human proportion), published in Nuremberg by Agnes Dürer, 1532, 1534, Morgan Library and Museum

1526: Like Leonardo, the Swiss physician Paracelsus champions observation and experience. Challenging the age-old notion that bodily health results from a balance of the four humors (melancholy, blood, phlegm, choler), he argues that disease has external causes. His ideas are disparaged, but history later proves him right.

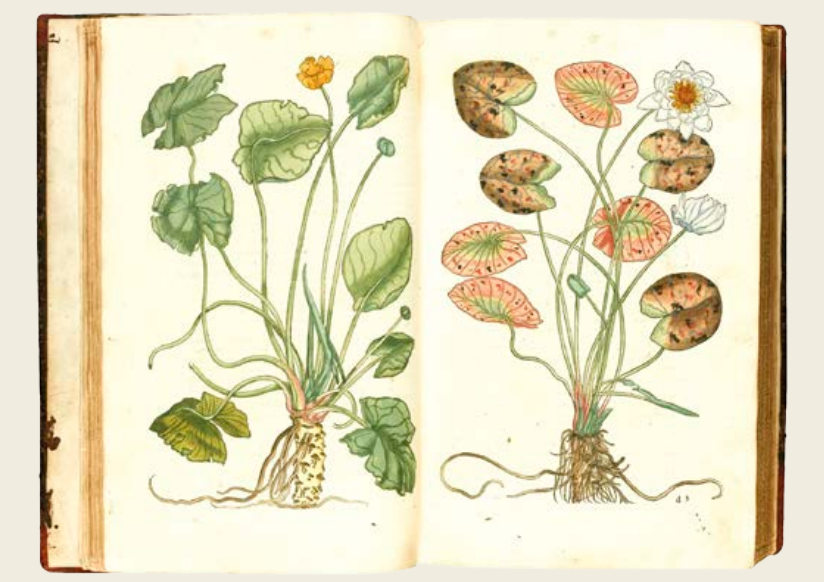
1530s: Echoing Leonardo's scientific approach, the German physician Georgius Agricola is the first to classify minerals and publishes widely on fossils, weights and measures, mining, metallurgy, and the plague.

1533: Padua's university becomes the first in Europe to offer a professorship in botany. The botanic gardens and herbaria (collections of dried plants) established for study and experimentation reflect Leonardo's insistence on direct observation of nature.


Engraving from *De re metallica* (On the nature of metals), by Georgius Agricola, published in Basel, 1556, Museo Civico di Storia Naturale, Milan

1537: The Flemish mathematician, geographer, and cartographer Gerardus Mercator maps the sphere of the earth on a flat plane, revolutionizing mapmaking and navigation.

1543: Copernicus publishes his theory of a sun-centered universe.


Hand-colored woodcuts by Hans Weiditz from *Herbarium vivae icones* by Otto Brunfels, 1532, private collection

1550: Giorgio Vasari publishes his *Lives of the Artists*, a compendium of biographies of Italian artists, which remains a foundational—and entertaining—text in art history. Of Leonardo, he writes, "So great was his genius, and such its growth, that to whatever difficulties he turned his mind, he solved them with ease."