16

Toward a New Worldview

1540–1789

The intellectual developments of the sixteenth and seventeenth centuries created the modern worldview that the West continues to hold—and debate—to this day. In this period, fundamentally new ways of understanding the natural world emerged. Those leading the changes saw themselves as philosophers and referred to their field of study as "natural philosophy." Nineteenth-century scholars hailed these achievements as a "Scientific Revolution" that produced modern science as we know it. The new science entailed the search for precise knowledge of the physical world based on the union of experimental observations with sophisticated mathematics. Whereas medieval scholars looked to authoritative texts like the Bible or the classics, early modern natural philosophers performed experiments and relied on increasingly complex mathematical calculations. The resulting conception of the universe and its laws remained in force until Einstein's discoveries at the beginning of the twentieth century.

In the eighteenth century philosophers extended the use of reason from the study of nature to human society. They sought to bring the light of reason to bear on the darkness of prejudice, outmoded traditions, and ignorance. Self-proclaimed members of an "Enlightenment" movement, they wished to bring the same progress to human affairs as their predecessors had brought to the understanding of the natural world. While the Scientific Revolution ushered in modern science, the Enlightenment created concepts of human rights, equality, progress, universalism, and tolerance that still guide Western societies today. At the same time, some people used their new understanding of nature and reason to proclaim their own superiority, thus rationalizing such attitudes as racism and male chauvinism. ■

Life During the Scientific Revolution. This 1768 painting by Joseph Wright captures the popularization of science and experimentation during the Enlightenment. Here, a scientist demonstrates the creation of a vacuum by withdrawing air from a flask, with the suffocating cockatoo serving as shocking proof of the experiment. (National Gallery, London/The Bridgeman Art Library)

CHAPTER PREVIEW

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Major Breakthroughs of the Scientific Revolution
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Important Changes in Scientific Thinking
What intellectual and social changes occurred as a result of the Scientific Revolution?

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Major Breakthroughs of the Scientific Revolution

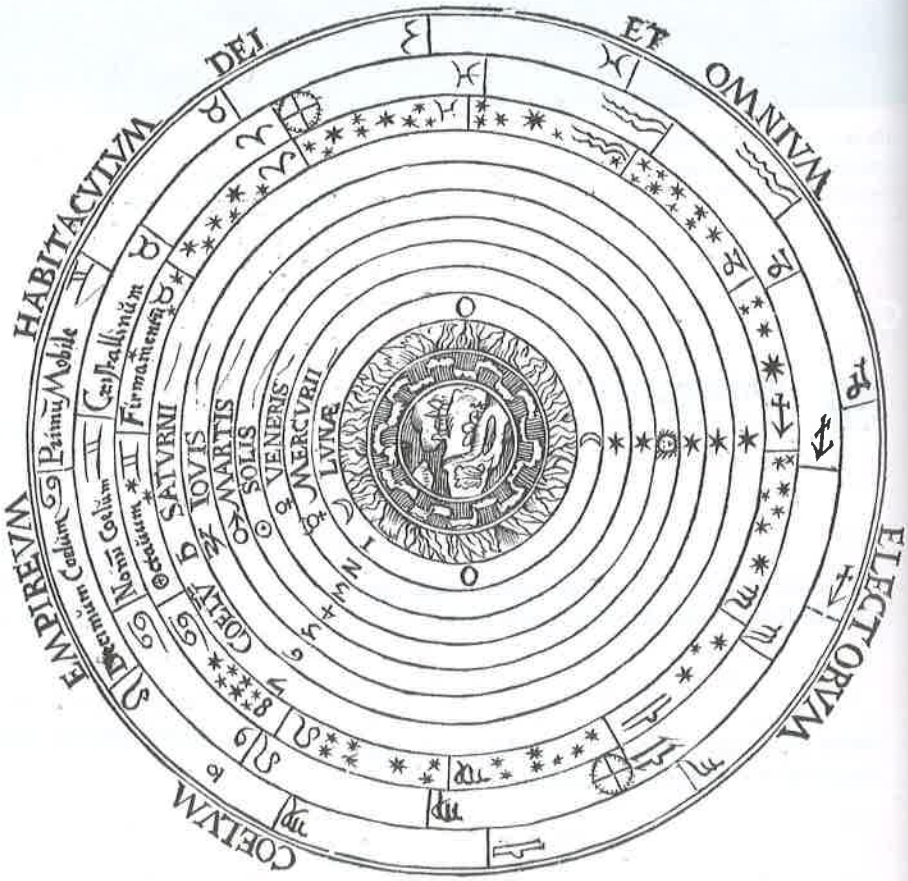
What revolutionary discoveries were made in the sixteenth and seventeenth centuries?

Until the middle of the sixteenth century, Europeans relied on an understanding of motion and matter drawn from the ancient Greek philosopher Aristotle and adapted to Christian theology. The rise of the university, along with the intellectual vitality of the Renaissance and technological advancements, inspired scholars to make closer observations and seek better explanations. From the sun-centered universe proposed by the Polish astronomer Nicolaus Copernicus to the great synthesis of physics and astronomy accomplished by the English scientist Isaac Newton, a revolutionary new understanding of the universe had emerged by the end of the seventeenth century. Hailed today as pioneers of a modern worldview, the major figures of the Scientific Revolution were for the most part devout Christians who saw their work as heralding the glory of creation and who combined older traditions of magic, astrology, and alchemy with their pathbreaking experimentation.

natural philosophy
An early modern term for the study of the nature of the universe, its purpose, and how it functioned; it encompassed what we would call "science" today.

Scientific Thought in 1500

The term *science* as we use it today came into use only in the nineteenth century. Prior to the Scientific Revolution, many different scholars and practitioners were involved in aspects of what came together to form science. One of the most important disciplines was **natural philosophy**, which focused on fundamental questions about the nature of the universe, its purpose, and how it functioned. In the early 1500s natural philosophy was still based primarily on the ideas of Aristotle, the great Greek philosopher of the fourth century B.C.E. Medieval theologians such as Thomas Aquinas brought Aristotelian philosophy into harmony with Christian doctrines. According to the revised Aristotelian view, a motionless earth was fixed at the center of the universe and was encompassed by ten separate concentric crystal spheres that revolved around it. In the first eight spheres were embedded, in turn, the moon, the sun, the five known planets, and the fixed stars. Then followed two spheres added during the Middle Ages to account for slight changes in the positions of the stars over the centuries. Beyond



The Aristotelian Universe as Imagined in the Sixteenth Century A round earth is at the center, surrounded by spheres of water, air, and fire. Beyond this small nucleus, the moon, the sun, and the five planets were embedded in their own rotating crystal spheres, with the stars sharing the surface of one enormous sphere. Beyond, the heavens were composed of unchanging ether. (Universal History Archive/UIG/The Bridgeman Art Library)

Chronology

ca. 1540–1700	Scientific Revolution
ca. 1690–1789	Enlightenment
ca. 1700–1800	Growth of book publishing
1720–1780	Rococo style in art and decoration
1740–1748	War of the Austrian Succession
1740–1780	Reign of the empress Maria Theresa of Austria
1740–1786	Reign of Frederick the Great of Prussia
ca. 1740–1789	Salons led by Parisian elites
1751–1772	Philosophes publish *Encyclopedia: The Rational Dictionary of the Sciences, the Arts, and the Crafts*
1756–1763	Seven Years' War
1762–1796	Reign of Catherine the Great of Russia
1780–1790	Reign of Joseph II of Austria
1791	Establishment of the Pale of Settlement

the tenth sphere was Heaven, with the throne of God and the souls of the saved. Angels kept the spheres moving in perfect circles.

Aristotle's cosmology made intellectual sense, but it could not account for the observed motions of the stars and planets and, in particular, provided no explanation for the apparent backward motion of the planets (which we now know occurs because planets closer to the sun periodically overtake the earth on their faster orbits). The great second-century scholar Ptolemy, a Hellenized Egyptian (see Chapter 14), offered a cunning solution to this dilemma. According to Ptolemy, the planets moved in small circles, called epicycles, each of which moved in turn along a larger circle, or deferent. Ptolemaic astronomy was less elegant than Aristotle's neat nested circles and required complex calculations, but it provided a surprisingly accurate model for predicting planetary motion.

Aristotle's views, revised by medieval philosophers, also dominated thinking about physics and motion on earth. Aristotle had distinguished sharply between the world of the celestial spheres and that of the earth—the sublunar world. The spheres consisted of a perfect, incorruptible "quintessence," or fifth essence. The sublunar world, however, was made up of four imperfect, changeable elements. The "light" elements (air and fire) naturally moved upward, while the "heavy" elements (water and earth) naturally moved downward. These natural directions of motion did not always prevail, however, for elements were often mixed together and could be affected by an outside force such as a human being. Aristotle and his followers also believed that a uniform force moved an object at a constant speed and that the object would stop as soon as that force was removed.

Natural philosophy was considered distinct from and superior to mathematics and mathematical disciplines like astronomy, optics, and mechanics, and Aristotle's ideas about the cosmos were accepted, with revisions, for two thousand years. His views offered a commonsense explanation for what the eye actually saw. Aristotle's science as interpreted by Christian theologians also fit neatly with Christian doctrines. It established a home for God and a place for Christian souls. It put human beings at the center of the universe and made them the critical link in a "great chain of being" that stretched from the throne of God to the lowliest insect on earth. This approach to the natural world was thus a branch of theology, and it reinforced religious thought.

Origins of the Scientific Revolution

Why did Aristotelian teachings give way to new views about the universe? The Scientific Revolution drew on long-term developments in European culture, as well as borrowings from Arabic scholars. The first important development was the medieval university. By the thirteenth century permanent universities had been established in western Europe to train the lawyers, doctors, and church leaders society required. By 1300 philosophy—including Aristotelian natural philosophy—had taken its place alongside law, medicine, and theology. Medieval philosophers acquired a limited but real independence from theologians and a sense of free inquiry.

Medieval universities drew on rich traditions of Islamic learning. With the expansion of Islam into lands of the Byzantine Empire in the seventh and eighth centuries, the Muslim world had inherited ancient Greek learning, to which Islamic scholars added their own commentaries and new discoveries. Many Greek texts, including many works of the philosopher Aristotle, which were lost to the West after the fall of the Western Roman Empire in the fifth century, re-entered circulation through translation from the Arabic in the twelfth century; these became the basis for the curriculum of the medieval universities. In the fourteenth and fifteenth centuries leading universities established new professorships of mathematics, astronomy, and optics within their faculties of philosophy. The prestige of the new fields was low, but the stage was set for the union

of mathematics with natural philosophy that was to be a hallmark of the Scientific Revolution.

The Renaissance also stimulated scientific progress. Renaissance patrons played a role in funding scientific investigations, as they did for art and literature. Renaissance artists' turn toward realism and their use of geometry to convey three-dimensional perspective encouraged scholars to practice close observation and to use mathematics to describe the natural world. The quest to restore the glories of the ancient past led to the rediscovery of even more classical texts, such as Ptolemy's *Geography* (see Chapter 14), which had been preserved in the Byzantine Empire and was translated into Latin around 1410. The encyclopedic treatise on botany by the ancient Greek philosopher Theophrastus was rediscovered in the 1450s, moldering on the shelves of the Vatican library. The fall of Constantinople to the Muslim Ottomans in 1453 resulted in a great influx of little-known Greek works, as Christian scholars fled to Italy with their precious texts.

Developments in technology also encouraged the emergence of the Scientific Revolution. The rise of printing in the mid-fifteenth century provided a faster and less expensive way to circulate knowledge across Europe. Fascination with the new discoveries being made in Asia and the Americas greatly increased the demand for printed material. Publishers found an eager audience for the books and images they issued about unknown peoples, plants, animals, and other new findings.

The navigational problems of long sea voyages in the age of overseas expansion, along with the rise of trade and colonization, led to their own series of technological innovations. As early as 1484 the king of Portugal appointed a commission of mathematicians to perfect tables to help seamen find their latitude. Navigation and cartography were also critical in the development of many new scientific instruments, such as the telescope, barometer, thermometer, pendulum clock, microscope, and air pump. Better instruments, which permitted more accurate observations, enabled the rise of experimentation as a crucial method of the Scientific Revolution.

Recent historical research has also focused on the contribution to the Scientific Revolution of practices that no longer belong to the realm of science, such as astrology. For most of human history, interest in astronomy was inspired by the belief that the changing relationships between planets and stars influence events on earth. This belief was held in Europe up to and during the Scientific Revolution (and continues among some people today). Many of the most celebrated astronomers were also astrologers and spent much time devising horoscopes for their patrons. Used as a diagnostic tool in medicine, astrology formed a regular part of the curriculum of medical schools.

Copernican hypothesis
The idea that the sun, not the earth, was the center of the universe.

Centuries-old practices of magic and alchemy also remained important traditions for natural philosophers. Unlike modern-day conjurers, the practitioners of magic strove to understand and control hidden connections they perceived among different elements of the natural world, such as that between a magnet and iron. The idea that objects possessed invisible or "occult" qualities that allowed them to affect other objects through their innate "sympathy" with each other was a particularly important legacy of the magical tradition. Belief in occult qualities—or numerology or cosmic harmony—was not antithetical to belief in God. On the contrary, adherents believed that only a divine creator could infuse the universe with such meaningful mystery.

The Copernican Hypothesis

The desire to explain and thereby glorify God's handiwork led to the first great departure from the medieval system. This was the work of the Polish cleric Nicolaus Copernicus (1473–1543). As a young man Copernicus was drawn to the vitality of the Italian Renaissance. After studies at the University of Kraków, he departed for Italy, where he studied astronomy, medicine, and church law at the famed universities of Bologna, Padua, and Ferrara. Copernicus noted that astronomers still depended on the work of Ptolemy for their most accurate calculations, but he felt that Ptolemy's cumbersome and occasionally inaccurate rules detracted from the majesty of a perfect creator. He preferred an alternative ancient Greek idea: that the sun, rather than the earth, was at the center of the universe.

Finishing his university studies and returning to a position in church administration in East Prussia, Copernicus worked on his hypothesis from 1506 to 1530. Without questioning the Aristotelian belief in crystal spheres or the idea that circular motion was divine, Copernicus theorized that the stars and planets, including the earth, revolved around a fixed sun. Desiring to be certain of his shocking claims before revealing them to the world, Copernicus did not publish his *On the Revolutions of the Heavenly Spheres* until 1543, the year of his death.

The **Copernican hypothesis** had enormous scientific and religious implications, many of which the conservative Copernicus did not anticipate. First, it put the stars at rest, their apparent nightly movement simply a result of the earth's rotation. Thus it destroyed the main reason for believing in crystal spheres capable of moving the stars around the earth. Second, Copernicus's theory suggested a universe of staggering size. If in the course of a year the earth moved around the sun and yet the stars appeared to remain in the same place, then

the universe was unthinkably large. Third, by using mathematics, instead of philosophy, to justify his theories, he challenged the traditional hierarchy of the disciplines. Finally, by characterizing the earth as just another planet, Copernicus destroyed the basic idea of Aristotelian physics—that the earthly sphere was quite different from the heavenly one. Where then were Heaven and the throne of God?

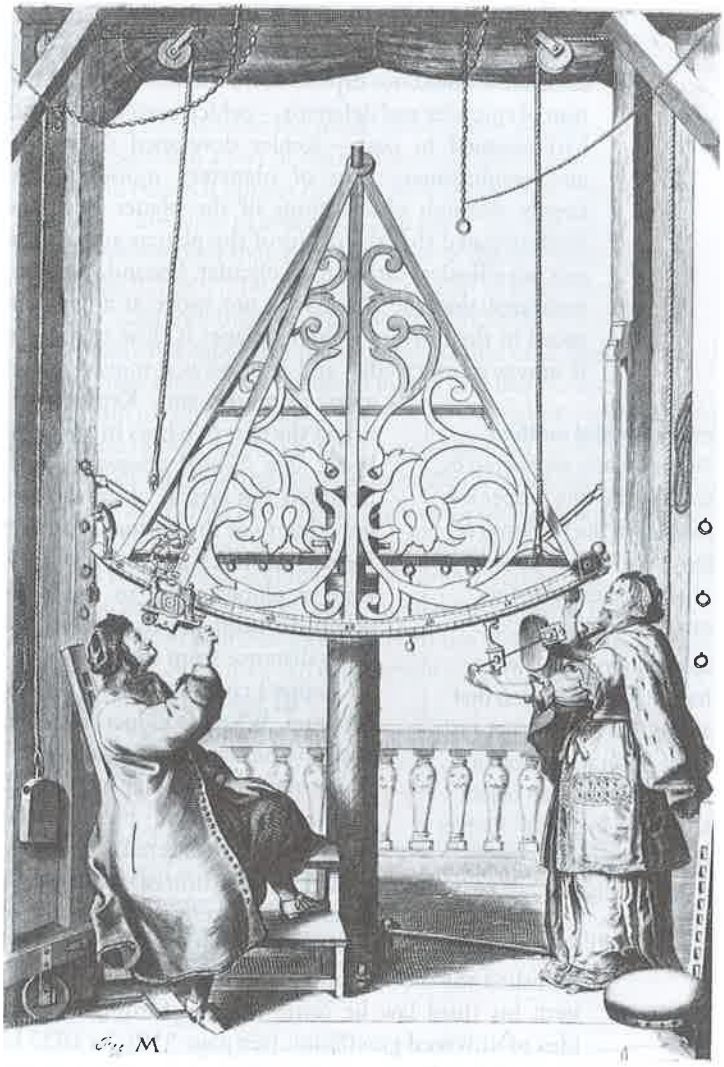
Religious leaders varied in their response to Copernicus's theories. A few Protestant scholars became avid Copernicans, while others accepted some elements of his criticism of Ptolemy, but firmly rejected the notion that the earth moved, a doctrine that contradicted the literal reading of some passages of the Bible. Among Catholics, Copernicus's ideas drew little attention prior to 1600. Because the Catholic Church had never held to literal interpretations of the Bible, it did not officially declare the Copernican hypothesis false until 1616.

Other events were almost as influential in creating doubts about traditional astronomy. In 1572 a new star appeared and shone very brightly for almost two years. The new star, which was actually a distant exploding star, made an enormous impression on people. It seemed to contradict the idea that the heavenly spheres were unchanging and therefore perfect. In 1577 a new comet suddenly moved through the sky, cutting a straight path across the supposedly impenetrable crystal spheres. It was time, as a sixteenth-century scientific writer put it, for "the radical renovation of astronomy."[1]

Brahe, Kepler, and Galileo: Proving Copernicus Right

One astronomer who agreed with Copernicus was Tycho Brahe (TEE-koh BRAH-hee) (1546–1601). Born into a Danish noble family, Brahe became passionately interested in astronomy as a young boy and spent many nights gazing at the skies. Completing his studies abroad and returning to Denmark, he established himself as Europe's leading astronomer with his detailed observations of the new star of 1572. Aided by generous grants from the king of Denmark, Brahe built the most sophisticated observatory of his day.

Upon the king's death, Brahe acquired a new patron in the Holy Roman emperor Rudolph II and built a new observatory in Prague. In return for the emperor's support, he pledged to create new and improved tables of planetary motions, dubbed the *Rudolphine Tables*. For twenty years Brahe meticulously observed the stars and planets with the naked eye, compiling much more complete and accurate data than ever before. His limited understanding of mathematics and his sudden death in 1601, however, prevented him from making much sense out of his mass of data. Part Ptolemaic, part Copernican, he believed that all the planets except the earth revolved around the sun and that the entire group of sun and planets revolved in turn around the earth-moon system.



Hevelius and His Wife Portable sextants were used to chart a ship's position at sea by measuring the altitude of celestial bodies above the horizon. Astronomers used much larger sextants to measure the angular distances between two bodies. Here, Johannes Hevelius makes use of the great brass sextant at the Danzig observatory, with the help of his wife, Elisabetha. Six feet in radius, this instrument was closely modeled on the one used by Tycho Brahe. (f Typ 620.73.451, Houghton Library, Harvard College Library)

It was left to Brahe's young assistant, Johannes Kepler (1571–1630), to rework Brahe's mountain of observations. From a minor German noble family, Kepler suffered a bout of smallpox as a small child, leaving him with permanently damaged hands and eyesight. A brilliant mathematician, Kepler was inspired by his belief that the universe was built on mystical mathematical relationships and a musical harmony of the heavenly bodies.

Kepler's examination of his predecessor's meticulously recorded findings convinced him that Ptolemy's astronomy could not explain them. Abandoning the notion of epicycles and deferents—which even Copernicus had retained in part—Kepler developed three new and revolutionary laws of planetary motion. First, largely through observations of the planet Mars, he demonstrated that the orbits of the planets around the sun are elliptical rather than circular. Second, he demonstrated that the planets do not move at a uniform speed in their orbits. When a planet is close to the sun it moves more rapidly, and it slows as it moves farther away from the sun. Kepler published the first two laws in his 1609 book, *The New Astronomy*, which heralded the arrival of an entirely new theory of the cosmos. In 1619 Kepler put forth his third law: the time a planet takes to make its complete orbit is precisely related to its distance from the sun.

experimental method The approach, pioneered by Galileo, that the proper way to explore the workings of the universe was through repeatable experiments rather than speculation.

law of inertia A law formulated by Galileo that states that motion, not rest, is the natural state of an object, and that an object continues in motion forever unless stopped by some external force.

Kepler's contribution was monumental. Whereas Copernicus had used mathematics to describe planetary movement, Kepler proved mathematically the precise relations of a sun-centered (solar) system. He thus united for the first time the theoretical cosmology of natural philosophy with mathematics. His work demolished the old system of Aristotle and Ptolemy, and with his third law he came close to formulating the idea of universal gravitation (see page 510). In 1627 he also fulfilled Brahe's pledge by completing the *Rudolphine Tables* begun so many years earlier. These tables were used by astronomers for many years.

Kepler was a genius with many talents. Beyond his great contribution to astronomy, he pioneered the field of optics. He was the first to explain the role of refraction within the eye in creating vision, and he invented an improved telescope. He was also a great mathematician whose work furnished the basis for integral calculus and advances in geometry.

Kepler was not, however, the consummate modern scientist that these achievements suggest. His duties as court mathematician included casting horoscopes, and he based his own daily life on astrological principles. He also wrote at length on cosmic harmonies and explained, for example, elliptical motion through ideas about the beautiful music created by the combined motion of the planets. Kepler's fictional account of travel to the moon, written partly to illustrate the idea of a non-earth-centered universe, caused controversy and may have contributed to the arrest and trial of his mother as a witch in 1620. Kepler also suffered deeply as a result of his unorthodox brand of Lutheranism, which led to his rejection by both Lutherans and Catholics. His career exemplifies the complex interweaving of ideas and beliefs in the emerging science of his day.

While Kepler was unraveling planetary motion, a young Florentine named Galileo Galilei (1564–1642) was challenging all the old ideas about motion. Like Kepler and so many early scientists, Galileo was a poor nobleman first marked for a religious career. Instead, his fascination with mathematics led to a professorship in which he examined motion and mechanics in a new way. His great achievement was the elaboration and consolidation of the **experimental method**. That is, rather than speculate about what might or should happen, Galileo conducted controlled experiments to find out what actually did happen.

In his early experiments, Galileo focused on deficiencies in Aristotle's theories of motion. He measured the movement of a rolling ball across a surface, repeating the action again and again to verify his results. In his famous acceleration experiment, he showed that a uniform force—in this case, gravity—produced a uniform acceleration. Through another experiment, he formulated the **law of inertia**. He found that rest was not the natural state of objects. Rather, an object continues in motion forever unless stopped by some external force. His discoveries proved Aristotelian physics wrong.

Galileo then applied the experimental method to astronomy. On hearing details about the invention of the telescope in Holland, Galileo made one for himself and trained it on the heavens. He quickly discovered the first four moons of Jupiter, which clearly suggested that Jupiter could not possibly be embedded in any impenetrable crystal sphere as Aristotle and Ptolemy maintained. This discovery provided new evidence for the Copernican theory, in which Galileo already believed. Galileo then pointed his telescope at the moon. He wrote in 1610 in *The Sidereal Messenger*: "By the aid of a telescope anyone may behold [the Milky Way] in a manner which so distinctly appeals to the senses that all the disputes which have tormented philosophers through so many ages are exploded by the irrefutable evidence of our eyes, and we are freed from wordy disputes upon the subject."[2] (See "Primary Source 16.1: Galileo Galilei, *The Sidereal Messenger*," at right.)

Reading these famous lines, one feels a crucial corner in Western civilization being turned. No longer should one rely on established authority. A new method of learning and investigating was being developed, one that proved useful in any field of inquiry. A historian investigating documents of the past, for example, is not so different from a Galileo studying stars and rolling balls.

In 1597, when Johannes Kepler sent Galileo an early publication defending Copernicus, Galileo replied that it was too dangerous to express his support for helio-

PRIMARY SOURCE 16.1

Galileo Galilei, *The Sidereal Messenger*

In this passage from The Sidereal Messenger *(1610), Galileo Galilei recounts his experiments to build a telescope and his observations of the moon. By discovering the irregularity of the moon's surface, Galileo disproved a central tenet of medieval cosmography: that the heavens were composed of perfect, unblemished spheres essentially different from the base matter of earth.*

"About ten months ago a report reached my ears that a Dutchman had constructed a telescope, by the aid of which visible objects, although at a great distance from the eye of the observer, were seen distinctly as if near. . . . A few days after, I received confirmation of the report in a letter written from Paris . . . , which finally determined me to give myself up first to inquire into the principle of the telescope, and then to consider the means by which I might compass [achieve] the invention of a similar instrument, which a little while after I succeeded in doing, through deep study of the theory of refraction; and I prepared a tube, at first of lead, in the ends of which I fitted two glass lenses, both plane on one side, but on the other side one spherically convex, and the other concave. . . . At length, by sparing neither labour nor expense, I succeeded in constructing for myself an instrument so superior that objects seen through it appear magnified nearly a thousand times, and more than thirty times nearer than if viewed by the natural powers of sight alone. . . .

Let me speak first of the surface of the moon, which is turned towards us. For the sake of being understood more easily, I distinguish two parts in it, which I call respectively the brighter and the darker. The brighter part seems to surround and pervade the whole hemisphere, but the darker part, like a sort of cloud, discolours the moon's surface and makes it appear covered with spots. Now these spots . . . are plain to every one, and every age has seen them, wherefore I shall call them *great* or *ancient* spots, to distinguish them from other spots, smaller in size, but so thickly scattered that they sprinkle the whole surface of the moon, but especially the brighter portion of it. These spots have never been observed by any one before me, and from my observations of them, often repeated, I have been led to that opinion which I have expressed, namely, that I feel sure that the surface of the moon is not perfectly smooth, free from inequalities and exactly spherical, as a large school of philosophers considers with regard to the moon and the other heavenly bodies, but that, on the contrary, it is full of inequalities, uneven, full of hollows and protuberances, just like the surface of the earth itself, which is varied everywhere by lofty mountains and deep valleys."

EVALUATE THE EVIDENCE

1. What did the telescope permit Galileo to see on the moon that was not visible to the naked eye, and how did he interpret his observations?
2. Why were Galileo's observations so important to the destruction of the Ptolemaic universe?

Source: Galileo Galilei, *The Sidereal Messenger* (London: Rivingtons, 1880), pp. 10–11, 14–15.

centrism publicly. The rising fervor of the Catholic Reformation increased the church's hostility to such radical ideas, and in 1616 the Holy Office placed the works of Copernicus and his supporters, including Kepler, on a list of books Catholics were forbidden to read. The accompanying decree declared that belief in a heliocentric world was "foolish and absurd, philosophically false and formally heretical."[3]

Galileo was a devout Catholic who sincerely believed that his theories did not detract from the perfection of God. Out of caution he silenced his beliefs for several years, until in 1623 he saw new hope with the ascension of Pope Urban VIII, a man sympathetic to developments in the new science. However, Galileo's 1632 *Dialogue on the Two Chief Systems of the World* went too far. Published in Italian and widely read, this work openly lampooned the traditional views of Aristotle and Ptolemy and defended those of Copernicus. The papal Inquisition placed Galileo on trial for heresy. Imprisoned and threatened with torture, the aging Galileo recanted, "renouncing and cursing" his Copernican errors.

Newton's Synthesis

Despite the efforts of the church, by about 1640 the work of Brahe, Kepler, and Galileo had been largely accepted by the scientific community. The old Aristotelian astronomy and physics were in ruins, and several fundamental breakthroughs had been made. But the new findings failed to explain what forces controlled the movement of the planets and objects on earth. That challenge was taken up by English scientist Isaac Newton (1642–1727).

Newton was born into the lower English gentry in 1642, and he enrolled at Cambridge University in 1661. A genius who spectacularly united the experimental and theoretical-mathematical sides of modern

science, Newton was an intensely devout, albeit nonorthodox Christian, who privately rejected the doctrine of the Trinity. Newton was also fascinated by alchemy. He left behind thirty years' worth of encoded journals recording experiments to discover the elixir of life and a way to change base metals into gold and silver. He viewed alchemy as one path, alongside mathematics and astronomy, to the truth of God's creation. Like Kepler and other practitioners of the Scientific Revolution, he studied the natural world not for its own sake, but to understand the divine plan.

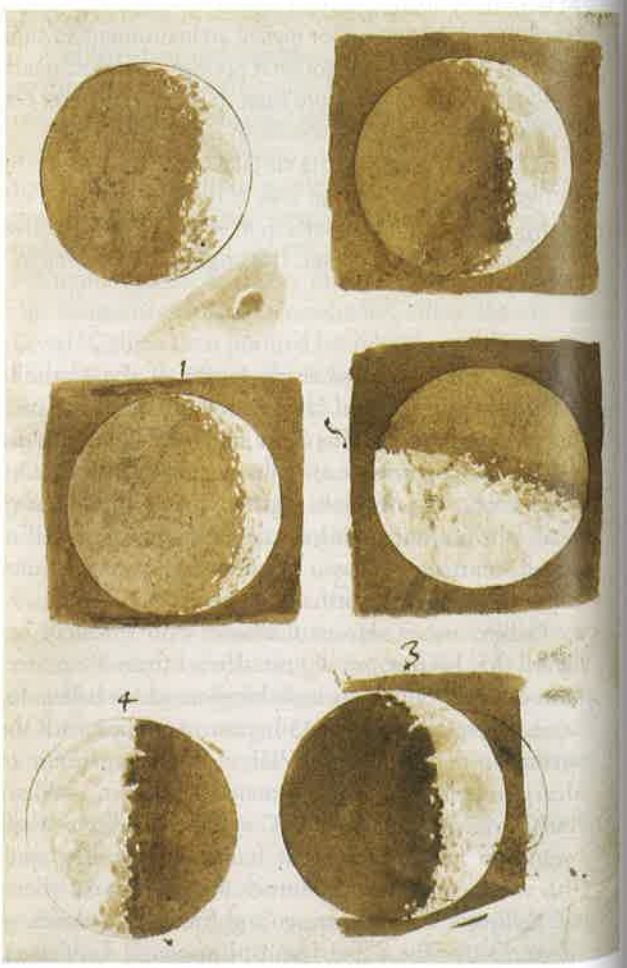
Newton arrived at some of his most basic ideas about physics between 1664 and 1666, during a break from studies at Cambridge caused by an outbreak of plague. As he later claimed, during this period he discovered his law of universal gravitation as well as the concepts of centripetal force and acceleration. Not realizing the significance of his findings, the young Newton did not publish them, and upon his return to Cambridge he took up the study of optics. It was in reference to his experiments in optics that Newton outlined his method of scientific inquiry most clearly, explaining the need for scientists "first to enquire diligently into the properties of things, and to establish these properties by experiment, and then to proceed more slowly to hypotheses for the explanation of them."[4]

law of universal gravitation Newton's law that all objects are attracted to one another and that the force of attraction is proportional to the objects' quantity of matter and inversely proportional to the square of the distance between them.

In 1684 Newton returned to physics and the preparation of his ideas for publication. The result appeared three years later in *Philosophicae Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy). Newton's towering accomplishment was a single explanatory system that could integrate the astronomy of Copernicus, as corrected by Kepler's laws, with the physics of Galileo and his predecessors. *Principia Mathematica* laid down Newton's three laws of motion, using a set of mathematical laws that explain motion and mechanics. These laws of dynamics are complex, and it took scientists and engineers two hundred years to work out all their implications.

The key feature of the Newtonian synthesis was the **law of universal gravitation**. According to this law, every body in the universe attracts every other body in

Galileo's Telescopic Observations of the Moon Among the many mechanical devices Galileo invented was a telescope that could magnify objects thirty times (other contemporary telescopes could magnify objects only three times). Using this telescope, he obtained the empirical evidence that proved the Copernican system. He sketched many illustrations of his observations, including the six phases of the moon shown here.
(moons: akg-images/Rabatti–Domingie; telescope: akg-images)



the universe in a precise mathematical relationship, whereby the force of attraction is proportional to the quantity of matter of the objects and inversely proportional to the square of the distance between them. The whole universe—from Kepler's elliptical orbits to Galileo's rolling balls—was unified in one coherent system. The German mathematician and philosopher Gottfried von Leibniz, with whom Newton contested the invention of calculus, was outraged by Newton's claim that the "occult" force of gravity could allow bodies to affect one another at great distances. Newton's religious faith, as well as his alchemical belief in the innate powers of certain objects, allowed him to dismiss such criticism.

Newton's synthesis of mathematics with physics and astronomy prevailed until the twentieth century and established him as one of the most important figures in the history of science. Yet, near the end of his life, this acclaimed figure declared: "I do not know what I may appear to the world; but to myself I seem to have been only like a boy, playing on the seashore, and diverting myself, in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."[5]

Important Changes in Scientific Thinking

What intellectual and social changes occurred as a result of the Scientific Revolution?

The creation of a new science was not accomplished by a handful of brilliant astronomers working alone. Scholars in many fields—medicine, chemistry, and botany, among others—used new methods to seek answers to long-standing problems, sharing their results in a community that spanned Europe. At the same time, monarchs and entrepreneurs launched explorations to uncover and understand the natural riches of newly conquered empires around the globe.

Bacon, Descartes, and the Scientific Method

One of the keys to the achievement of a new worldview in the seventeenth century was the development of better ways of obtaining knowledge about the world. Two important thinkers, Francis Bacon (1561–1626) and René Descartes (day-KAHRT) (1596–1650), were influential in describing and advocating for improved scientific methods based, respectively, on experimentation and mathematical reasoning.

English politician and writer Francis Bacon was the greatest early propagandist for the new experimental method. Rejecting the Aristotelian and medieval method of using speculative reasoning to build general theories, Bacon argued that new knowledge had to be pursued through empirical research. The researcher who wants to learn more about leaves or rocks, for example, should not speculate about the subject but should rather collect a multitude of specimens and then compare and analyze them to derive general principles. Bacon formalized the empirical method, which had already been used by Brahe and Galileo, into the general theory of inductive reasoning known as **empiricism**. Bacon's work, and his prestige as lord chancellor under James I, led to the widespread adoption of what was called "experimental philosophy" in England after his death. In 1660 followers of Bacon created the Royal Society (still in existence), which met weekly to conduct experiments and discuss the latest findings of scholars across Europe.

empiricism A theory of inductive reasoning that calls for acquiring evidence through observation and experimentation rather than deductive reason and speculation.

On the continent, more speculative methods retained support. The French philosopher René Descartes was a multitalented genius who made his first great discovery in mathematics. As a twenty-three-year-old soldier serving in the Thirty Years' War, he experienced a life-changing intellectual vision one night in 1619. Descartes saw that there was a perfect correspondence between geometry and algebra and that geometrical spatial figures could be expressed as algebraic equations and vice versa. A major step forward in the history of mathematics, Descartes's discovery of analytic geometry provided scientists with an important new tool.

Descartes used mathematics to elaborate a highly influential vision of the workings of the cosmos. Accepting Galileo's claim that all elements of the universe are composed of the same matter, Descartes began to investigate the basic nature of matter. Drawing on ancient Greek atomist philosophies, Descartes developed the idea that matter was made up of identical "corpuscules" that collided together in an endless series of motions. All occurrences in nature could be analyzed as matter in motion and, according to Descartes, the total "quantity of motion" in the universe was constant. Descartes's mechanistic view of the universe depended on the idea that a vacuum was impossible, which meant that every action had an equal reaction, continuing in an eternal chain reaction.

Although Descartes's hypothesis about the vacuum was proved wrong, his notion of a mechanistic universe intelligible through the physics of motion proved inspirational. Decades later, Newton rejected Descartes's idea of a full universe and several of his other ideas, but

retained the notion of a mechanistic universe as a key element of his own system.

Descartes's greatest achievement was to develop his initial vision into a whole philosophy of knowledge and science. The Aristotelian cosmos was appealing in part because it corresponded with the evidence of the human senses. When the senses were proven to be wrong, Descartes decided it was necessary to doubt them and everything that could reasonably be doubted, and then, as in geometry, to use deductive reasoning from self-evident truths, which he called "first principles," to ascertain scientific laws. Descartes's reasoning ultimately reduced all substances to "matter" and "mind"—that is, to the physical and the spiritual. The devout Descartes believed that God had endowed man with reason for a purpose and that rational speculation could provide a path to the truths of creation. His view of the world as consisting of two fundamental entities is known as **Cartesian dualism**. Descartes's thought was highly influential in France and the Netherlands, but less so in England, where experimental philosophy won the day.

Cartesian dualism
Descartes's view that all of reality could ultimately be reduced to mind and matter.

Both Bacon's inductive experimentalism and Descartes's deductive mathematical reasoning had their faults. Bacon's inability to appreciate the importance of mathematics and his obsession with practical results clearly showed the limitations of antitheoretical empiricism. Likewise, some of Descartes's positions demonstrated the inadequacy of rigid, dogmatic rationalism. For example, he believed that it was possible to deduce the whole science of medicine from first principles. Although insufficient on their own, Bacon's and Descartes's extreme approaches are combined in the modern scientific method, which began to crystallize in the late seventeenth century.

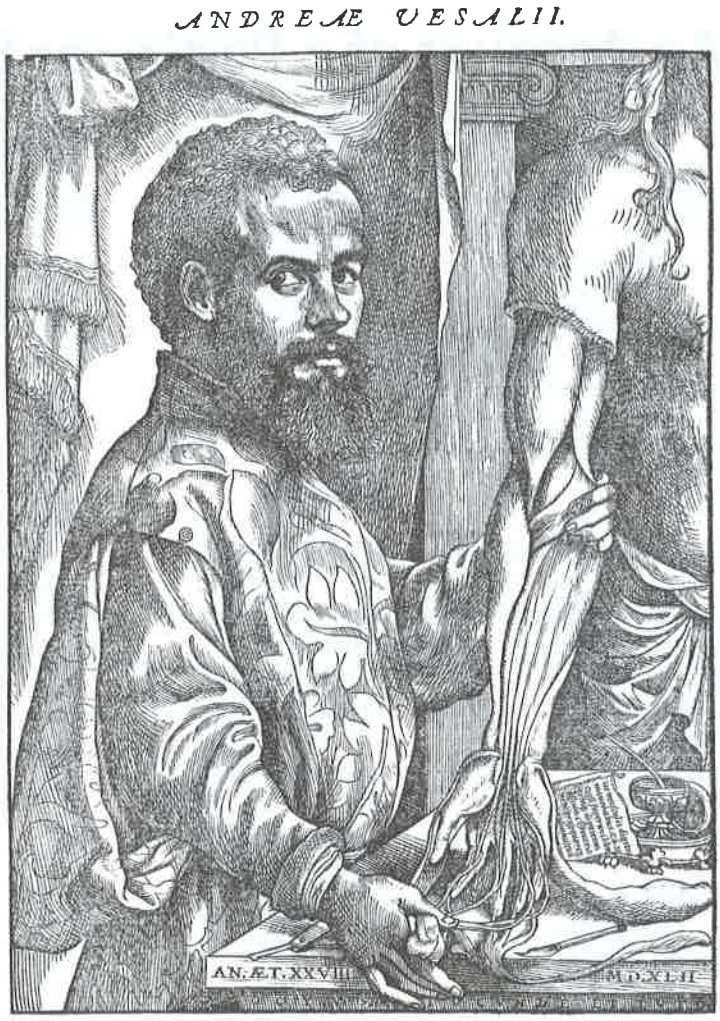
Major Contributors to the Scientific Revolution

Nicolaus Copernicus (1473–1543)	*On the Revolutions of the Heavenly Spheres* (1543); theorized that the sun, rather than the earth, was the center of the galaxy
Paracelsus (1493–1541)	Swiss physician and alchemist who pioneered the use of chemicals and drugs to address illness
Andreas Vesalius (1514–1564)	*On the Structure of the Human Body* (1543)
Tycho Brahe (1546–1601)	Built observatory and compiled data for the *Rudolphine Tables*, a new table of planetary data
Francis Bacon (1561–1626)	Advocated experimental method, formalizing theory of inductive reasoning known as empiricism
Galileo Galilei (1564–1642)	Used telescopic observation to provide evidence for Copernican hypothesis; experimented to formulate laws of physics, such as inertia
Johannes Kepler (1571–1630)	Used Brahe's data to mathematically prove the Copernican hypothesis; his new laws of planetary motion united for the first time natural philosophy and mathematics; completed the *Rudolphine Tables* in 1627
William Harvey (1578–1657)	Discovery of circulation of blood (1628)
René Descartes (1596–1650)	Used deductive reasoning to formulate the theory of Cartesian dualism
Robert Boyle (1627–1691)	Boyle's law (1662) governing the pressure of gases
Isaac Newton (1642–1727)	*Principia Mathematica* (1687); set forth the law of universal gravitation, synthesizing previous findings of motion and matter

Medicine, the Body, and Chemistry

The Scientific Revolution soon inspired renewed study of the microcosm of the human body. For many centuries the ancient Greek physician Galen's explanation of the body carried the same authority as Aristotle's account of the universe. According to Galen, the body contained four humors: blood, phlegm, black bile, and yellow bile. Illness was believed to result from an imbalance of humors, which is why doctors frequently prescribed bloodletting to expel excess blood.

Swiss physician and alchemist Paracelsus (1493–1541) was an early proponent of the experimental method in medicine and pioneered the use of chemicals and drugs to address what he saw as chemical, rather than humoral, imbalances. Another experimentalist, Flemish physician Andreas Vesalius (1516–1564), studied anatomy by dissecting human bodies, often those of executed criminals. In 1543, the same year Copernicus published *On the Revolutions*, Vesalius issued his masterpiece, *On the Structure of the Human Body*. Its two hundred precise drawings revolutionized the understanding of human anatomy. The experimen-



Frontispiece to *De Humani Corporis Fabrica* (On the Structure of the Human Body) The frontispiece to Vesalius's pioneering work, published in 1543, shows him dissecting a corpse before a crowd of students. This was a revolutionary new hands-on approach for physicians, who usually worked from a theoretical, rather than a practical, understanding of the body. Based on direct observation, Vesalius replaced ancient ideas drawn from Greek philosophy with a much more accurate account of the structure and function of the body. (© SSPL/Science Museum/The Image Works)

tal approach also led English royal physician William Harvey (1578–1657) to discover the circulation of blood through the veins and arteries in 1628. Harvey was the first to explain that the heart worked like a pump and to explain the function of its muscles and valves.

Some decades later, Irishman Robert Boyle (1627–1691) helped found the modern science of chemistry. Following Paracelsus's lead, he undertook experiments to discover the basic elements of nature, which he believed was composed of infinitely small atoms. Boyle was the first to create a vacuum, thus disproving Descartes's belief that a vacuum could not exist in nature, and he discovered Boyle's law (1662), which states that the pressure of a gas varies inversely with volume.

Empire and Natural History

While the traditional story of the Scientific Revolution focuses exclusively on developments within Europe itself, and in particular on achievements in mathematical astronomy, more recently scholars have emphasized the impact of Europe's overseas empires on the accumulation and transmission of knowledge about the natural world. Thus, moving beyond Ptolemy's *Geography* (see Chapter 14) was as important for the emergence of modern science as overturning his cosmography.

Building on the rediscovery of Theophrastus's botanical treatise (see page 506) and other classical texts, early modern scholars published new works cataloguing forms of life in northern Europe, Asia, and the Americas that were unknown to the ancients. These encyclopedias of natural history included realistic drawings and descriptions that emphasized the usefulness of animal and plant species for trade, medicine, food, and other practical concerns.

Much of the new knowledge contained in such works resulted from scientific expeditions, often sponsored by European governments eager to learn about and profit from their imperial holdings. Spain took an early lead in such voyages, given their early conquests in the Americas (see Chapter 14). The physician of King Philip II of Spain spent seven years in New Spain in the 1560s recording thousands of plant species and interviewing local healers about their medicinal properties. Other countries followed suit as their global em-

PRIMARY SOURCE 16.2

"An Account of a Particular Species of Cocoon"

To disseminate its members' work, the Royal Society of England published the results of its meetings in the Philosophical Transactions of the Royal Society. *The passage below is excerpted from a presentation made to the society in the mid-eighteenth century by the Reverend Samuel Pullein, a graduate of Trinity College in Dublin. A relative of the governor of Jamaica, Pullein became fascinated by the idea of introducing silkworm cultivation to the American colonies. His presentation exemplifies the contribution of many minor enthusiasts to the progress of science in this period and the importance of colonialism to the new knowledge.*

"Having lately seen the aurelia of a particular species of caterpillar, I judged, from its texture and consistence, that there might be procured from it a silk not inferior to that of the common silk-worm in its quality, and in its quantity much superior. I have made some experiments on this new species of silk-pod, which strengthen this opinion.

This pod is about three inches and a quarter in length, and above one inch in diameter; its outward form not so regular an oval as that of the common silk-worm; its consistence somewhat like that of a dried bladder, when not fully blown; its colour of a reddish brown; its whole weight 21 grains.

Upon cutting open this outer integument, there appeared in the inside a pod completely oval, as that of the silk-worm. It was covered with some floss-silk, by which it was connected to the outer coat, being of the same colour. Its length was two inches; its diameter nearly one inch; and its weight nine grains.

The pod could not be easily unwinded, because it was perforated by the moth: but, upon putting it in hot water, I reeled off so much as sufficed to form a judgment of the strength and staple of its silk.

The single thread winded off the pod in the same manner as that of the common silk-worm; seeming in all respects as fine, and as tough. I doubled this thread so often as to contain twenty in thickness; and the compound thread was as smooth, as elastic, and as glossy, as that of the common silk-worm. I tried what weight it would bear; and it bore fifteen ounces and a half, and broke with somewhat less than sixteen, upon several trials. . . .

The caterpillar which produces this pod is a native of America. It was found in Pennsylvania: the pod was fixed to the small branch of a tree, which seemed to be either of the crab or hawthorn species. . . .

I do not conceive that it will be at all difficult to find out the caterpillar, or the tree it feeds on; or to reel such a quantity of the silk as shall, when woven into ribband, more fully demonstrate whether it be of that value which I judge it. For by comparing it with the *cocoon* of the wild Chinese silk-worm, from which an excellent species of silk is made, I have no doubt of its being the same species; and would be glad if, by this memorial, I could induce the people of America to make trial of it."

EVALUATE THE EVIDENCE

1. What is Pullein's aim in presenting his research to the Royal Society? How does he try to establish the credibility of his claims about the silkworm?
2. In what ways does this document belong to the "Scientific Revolution" as discussed in this chapter? What does Pullein's presentation tell us about the nature of "science" presented to the Royal Society in the mid-eighteenth century?

Source: "An Account of a Particular Species of Cocoon, or Silk-Pod, from America," Reverend Samuel Pullein, M.A., *Philosophical Transactions of the Royal Society* 15 (1759): 54–57.

pires expanded. (See "Primary Source 16.2: 'An Account of a Particular Species of Cocoon,'" above.)

Audiences at home eagerly read the accounts of naturalists, who braved the heat, insects, and diseases of tropical jungles to bring home exotic animal, vegetable, and mineral specimens. They heard much less about the many indigenous guides, translators, and practitioners of medicine and science who made these expeditions possible and who contributed rich local knowledge about animal and plant species. In this period the craze for collecting natural history specimens in Europe extended from aristocratic lords to middle-class amateurs. Many public museums, like the British Museum in London, began with the donation of a large private collection.

Science and Society

The rise of modern science had many consequences, some of which are still unfolding. First, it went hand in hand with the rise of a new social group—the international scientific community. Members of this community were linked together by common interests and shared values as well as by journals and the learned sci-

entific societies founded in many countries in the late seventeenth and eighteenth centuries. The personal success of scientists and scholars depended on making new discoveries, and science became competitive. Second, as governments intervened to support and sometimes direct research, the new scientific community became closely tied to the state and its agendas, a development strongly endorsed by Francis Bacon in England. In addition to England's Royal Society, academies of science were created under state sponsorship in Paris in 1666, Berlin in 1700, and later across Europe. At the same time, scientists developed a critical attitude toward established authority that would inspire thinkers to question traditions in other domains as well.

It was long believed that the Scientific Revolution had little relationship to practical concerns and the life of the masses until the late-eighteenth-century Industrial Revolution (see Chapter 20). More recently, historians have emphasized the crossover between the work of artisans and the rise of science, particularly in the development of the experimental method. Many craftsmen developed strong interest in emerging scientific ideas and, in turn, the practice of science in the seventeenth century often relied on artisans' expertise in making instruments and conducting precise experiments.

Some things did not change in the Scientific Revolution. Scholars have noted that nature was often depicted as a female, whose veil of secrecy needed to be stripped away and penetrated by male experts. New "rational" methods for approaching nature did not question traditional inequalities between the sexes—and may have worsened them in some ways. For example, the rise of universities and other professional institutions for science raised new barriers because most of these organizations did not accept women.

There were, however, a number of noteworthy exceptions. In Italy, universities and academies did offer posts to women, attracting some foreigners spurned at home. Women across Europe worked as makers of wax anatomical models and as botanical and zoological illustrators, like Maria Sibylla Merian. They were also very much involved in informal scientific communities, attending salons (see page 522), participating in scientific experiments, and writing learned treatises. Some female intellectuals became full-fledged members of the philosophical dialogue. In England, Margaret Cavendish, Anne Conway, and Mary Astell all contributed to debates about Descartes's mind-body dualism, among other issues. Descartes himself conducted an intellectual correspondence with the princess Elizabeth of Bohemia, of whom he stated: "I attach more weight to her judgment than to those messieurs the Doctors, who take for a rule of truth the opinions of Aristotle rather than the evidence of reason."[6]

Metamorphoses of the Caterpillar and Moth Maria Sibylla Merian (1647–1717), the stepdaughter of a Dutch painter, became a celebrated scientific illustrator in her own right. Her finely observed pictures of insects in the South American colony of Suriname introduced many new species. For Merian, science was intimately tied with art: she not only painted but also bred caterpillars and performed experiments on them. Her two-year stay in Suriname, accompanied by a teenage daughter, was a daring feat for a seventeenth-century woman. (akg-images)

By the time Louis XIV died in 1715, many of the scientific ideas that would eventually coalesce into a new worldview had been assembled. Yet Christian Europe was still strongly attached to its established political and social structures and its traditional spiritual beliefs. By 1775, however, a large portion of western Europe's educated elite had embraced the new ideas. This was the work of many men and women across Europe who participated in the Enlightenment, either as publishers, writers, and distributors of texts or as members of the eager public that consumed them.

The Enlightenment

What new ideas about society and human relations emerged in the Enlightenment, and what new practices and institutions enabled these ideas to take hold?

The Scientific Revolution was a crucial factor in the creation of the new worldview of the eighteenth-century **Enlightenment**. This worldview, which has played a large role in shaping the modern mind, grew out of a rich mix of diverse and often conflicting ideas that were debated in international networks. Despite the diversity, three central concepts stand at the core of Enlightenment thinking. The first and foremost idea was that the methods of natural science could and should be used to examine and understand all aspects of life. This was what intellectuals meant by *reason*, a favorite word of Enlightenment thinkers. Nothing was to be accepted on faith; everything was to be submitted to **rationalism**, a secular, critical way of thinking. A second important Enlightenment concept was that the scientific method was capable of discovering the laws of human society as well as those of nature. These tenets led to the third key idea, that of progress. Armed with the proper method of discovering the laws of human existence, Enlightenment thinkers believed, it was at least possible for human beings to create better societies and better people.

The Emergence of the Enlightenment

Loosely united by certain key ideas, the European Enlightenment (ca. 1690–1789) was a broad intellectual and cultural movement that gained strength gradually and did not reach its maturity until about 1750. Yet it was the generation that came of age between the publication of Newton's *Principia* in 1687 and the death of Louis XIV in 1715 that tied the crucial knot between the Scientific Revolution and a new outlook on life. Whereas medieval and Reformation thinkers had been concerned primarily with abstract concepts of sin and salvation, and Renaissance humanists had drawn their inspiration from the classical past, Enlightenment thinkers believed that their era had gone far beyond antiquity and that intellectual progress was very possible. Talented writers of that generation popularized hard-to-understand scientific achievements and set an agenda of human problems to be addressed through the methods of science.

Enlightenment The influential intellectual and cultural movement of the late seventeenth and eighteenth centuries that introduced a new worldview based on the use of reason, the scientific method, and progress.

rationalism A secular, critical way of thinking in which nothing was to be accepted on faith, and everything was to be submitted to reason.

Like the Scientific Revolution, the Enlightenment was also fueled by Europe's increased contacts with the wider world. In the wake of the great discoveries of the fifteenth and sixteenth centuries, the rapidly growing travel literature taught Europeans that the peoples of China, India, Africa, and the Americas all had their own very different beliefs and customs. Europeans shaved their faces and let their hair grow. Turks shaved their heads and let their beards grow. In Europe a man bowed before a woman to show respect. In Siam a man turned his back on a woman when he met her because it was disrespectful to look directly at her. Countless similar examples discussed in travel accounts helped change the perspective of educated Europeans. They began to look at truth and morality in relative, rather than absolute, terms. If anything was possible, who could say what was right or wrong?

The excitement of the Scientific Revolution also generated doubt and uncertainty, contributing to a widespread crisis in late-seventeenth-century European thought. In the wake of the devastation wrought by the Thirty Years' War, some people asked whether ideological conformity in religious matters was really necessary. Others skeptically asked if religious truth could ever be known with absolute certainty and concluded that it could not. The atmosphere of doubt spread from religious to political issues. This was a natural extension, since many rulers viewed religious dissent as a form of political opposition and took harsh measures to stifle unorthodox forms of worship. Thus, questioning religion inevitably led to confrontations with the state.

These concerns combined spectacularly in the career of Pierre Bayle (1647–1706), a French Protestant, or Huguenot, who took refuge from government persecution in the tolerant Dutch Republic. Bayle critically examined the religious beliefs and persecutions of the past in his *Historical and Critical Dictionary* (1697). Demonstrating that human beliefs had been extremely varied and very often mistaken, he concluded that nothing can ever be known beyond all doubt, a view known as skepticism. His very influential *Dictionary* was found in more private libraries of eighteenth-century France than any other book.

Like Bayle, many Huguenots fled France for the Dutch Republic, a center of early Enlightenment thought for people of many faiths. The Dutch Jewish philosopher Baruch Spinoza (1632–1677) borrowed Descartes's emphasis on rationalism and his methods of deductive reasoning, but rejected the French thinker's mind-body dualism. Instead, Spinoza came to believe that mind and body are united in one substance

and that God and nature were merely two names for the same thing. He envisioned a deterministic universe in which good and evil were merely relative values and our actions were shaped by outside circumstances, not free will. Spinoza was excommunicated by the relatively large Jewish community of Amsterdam for his controversial religious ideas, but he was heralded by his Enlightenment successors as a model of personal virtue and courageous intellectual autonomy.

The German philosopher and mathematician Gottfried Wilhelm von Leibniz (1646–1716), who had developed calculus independently of Isaac Newton (see page 511), refuted both Cartesian dualism and Spinoza's monism (the idea that there is only one substance in the universe). Instead, he adopted the idea of an infinite number of substances or "monads" from which all matter is composed. His *Theodicy* (1710) declared that ours must be "the best of all possible worlds" because it was created by an omnipotent and benevolent God. Leibniz's optimism was later ridiculed by the French philosopher Voltaire in *Candide or Optimism* (1759).

Out of this period of intellectual turmoil came John Locke's *Essay Concerning Human Understanding* (1690). In this work Locke (1632–1704), a physician and member of the Royal Society, brilliantly set forth a new theory about how human beings learn and form their ideas. Whereas Descartes, Spinoza, and Leibniz based their philosophies on deductive logic, Locke insisted that all ideas are derived from experience. The human mind at birth is like a blank tablet, or tabula rasa, on which the environment writes the individual's understanding and beliefs. Human development is therefore determined by education and social institutions. Locke's essay contributed to the theory of sensationalism, the idea that all human ideas and thoughts are produced as a result of sensory impressions. With his emphasis on the role of perception in the acquisition of knowledge, Locke provided a systematic justification of Bacon's emphasis on the importance of observation and experimentation. The *Essay Concerning Human Understanding* passed through many editions and translations and, along with Newton's *Principia*, was one of the dominant intellectual inspirations of the Enlightenment. Locke's equally important contribution to political theory, *Two Treatises of Civil Government* (1690), insisted on the sovereignty of the elected Parliament against the authority of the Crown (see Chapter 15).

The Influence of the Philosophes

Divergences among the early thinkers of the Enlightenment show that, while they shared many of the same premises and questions, the answers they found differed widely. The spread of this spirit of inquiry and debate owed a great deal to the work of the **philosophes** (fee-luh-ZAWFZ), a group of intellectuals who proudly proclaimed that they, at long last, were bringing the light of reason to their ignorant fellow humans. *Philosophe* is the French word for "philosopher," and in the mid-eighteenth century France became a hub of Enlightenment thought. There were at least three reasons for this. First, French was the international language of the educated classes, and France was the wealthiest and most populous country in Europe. Second, the rising unpopularity of King Louis XV and his mistresses generated growing discontent and calls for reform among the educated elite. Third, the French philosophes made it their goal to reach a larger audience of elites, many of whom were joined together in a concept inherited from the Renaissance known as the Republic of Letters—an imaginary transnational realm of the well educated.

philosophes A group of French intellectuals who proclaimed that they were bringing the light of knowledge to their fellow humans in the Age of Enlightenment.

One of the greatest philosophes, the baron de Montesquieu (mahn-tuhs-KYOO) (1689–1755), brilliantly pioneered this approach in *The Persian Letters*, an extremely influential social satire published in 1721 and considered the first major work of the French Enlightenment. It consisted of amusing letters supposedly written by two Persian travelers who as outsiders saw European customs in unique ways, thereby allowing Montesquieu a vantage point for criticizing existing practices and beliefs.

Having gained fame by using wit as a weapon against cruelty and superstition, Montesquieu turned to the study of history and politics. His interest was partly personal, for, like many members of the French robe nobility, he was disturbed by the growth in absolutism under Louis XIV (see Chapter 15). But Montesquieu was also inspired by the example of the physical sciences, and he set out to apply the critical method to the problem of government in *The Spirit of Laws* (1748). The result was a complex, comparative study of republics, monarchies, and despotisms.

Showing that forms of government were shaped by history and geography, Montesquieu focused on the conditions that would promote liberty and prevent tyranny. He argued for a separation of powers, with political power divided and shared by a variety of classes and legal estates. Admiring greatly the English balance of power, Montesquieu believed that in France the thirteen high courts—the *parlements*—were frontline defenders of liberty against royal despotism. Apprehensive about the uneducated poor, Montesquieu was clearly no democrat, but his theory of separation of powers had a great impact on the constitutions

of the young United States in 1789 and of France in 1791.

The most famous and perhaps most representative philosophe was François Marie Arouet, who was known by the pen name Voltaire (vohl-TAIR) (1694–1778). In his long career, this son of a comfortable middle-class family wrote more than seventy witty volumes, hobnobbed with royalty, and died a millionaire through shrewd speculations. His early career, however, was turbulent, and he was arrested on two occasions for insulting noblemen. Voltaire moved to England for three years in order to avoid a longer prison term in France, and there he came to share Montesquieu's enthusiasm for English liberties and institutions.

Returning to France, Voltaire had the great fortune of meeting Gabrielle-Emilie Le Tonnelier de Breteuil, marquise du Châtelet (SHAH-tuh-lay) (1706–1749), a noblewoman with a passion for science. Inviting Voltaire to live in her country house at Cirey in Lorraine and becoming his long-time companion (under the eyes of her tolerant husband), Madame du Châtelet studied physics and mathematics and published scientific articles and translations, including the first—and only—translation of Newton's *Principia* into French. (See "Primary Source 16.3: Du Châtelet, *Foundations of Physics*," at right.) Excluded from the Royal Academy of Sciences because she was a woman, Madame du Châtelet had no doubt that women's limited role in science was due to their unequal education. Discussing what she would do if she were a ruler, she wrote, "I would reform an abuse which cuts off, so to speak, half the human race. I would make women participate in all the rights of humankind, and above all in those of the intellect."[7]

While living at Cirey, Voltaire wrote works praising England and popularizing English science. He had witnessed Newton's burial at Westminster Abbey in 1727, and he lauded Newton as history's greatest man, for he had used his genius for the benefit of humanity. In the true style of the Enlightenment, Voltaire mixed the glorification of science and reason with an appeal for better individuals and institutions.

Yet, like almost all of the philosophes, Voltaire was a reformer, not a revolutionary, in politics. He pessimistically concluded that the best one could hope for in the way of government was a good monarch, since human beings "are very rarely worthy to govern themselves." He lavishly praised Louis XIV and conducted an enthusiastic correspondence with King Frederick the Great of Prussia, whom he admired as an enlightened monarch (see page 530). Nor did Voltaire believe in social and economic equality, insisting that the idea of making servants equal to their masters was "absurd and impossible." The only realizable equality, Voltaire thought, was that "by which the citizen only depends on the laws which protect the freedom of the feeble against the ambitions of the strong."[8]

Voltaire's philosophical and religious positions were much more radical than his social and political beliefs. In the tradition of Bayle, his writings challenged the Catholic Church and Christian theology at almost every point. Voltaire clearly believed in God, but, like many eighteenth-century Enlightenment thinkers, he was a deist, envisioning God as akin to a clockmaker

Madame du Châtelet The marquise du Châtelet was fascinated by the new world system of Isaac Newton. She helped spread Newton's ideas in France by translating his *Principia* and by influencing Voltaire, her companion for fifteen years until her death. (Private Collection/The Bridgeman Art Library)

PRIMARY SOURCE 16.3

Du Châtelet, *Foundations of Physics*

Gabrielle-Emilie Le Tonnelier de Breteuil, marquise du Châtelet, was a French noblewoman. Frustrated by her limited education as a girl, she befriended philosophes, studied advanced calculus and analytic geometry, and assiduously read the latest scientific publications. Madame du Châtelet translated Newton's Principia *into French and offered her own commentary on his ideas. The passage below is from her* Foundations of Physics *(1740), an overview of natural philosophy that she wrote for her son's education. She died of complications of childbirth at the age of forty-two.*

"Descartes appeared in that profound night like a star come to illuminate the universe. The revolution that this great man caused in the sciences is surely more useful, and perhaps even more memorable, than that of the greatest empires, one, it can be said, that human reason owes most to Descartes. For it is very much easier to find the truth, when once one is on the track of it, than to leave those of error. The geometry of this great man, his dioptrics, his method, are masterpieces of sagacity that will make his name immortal, and if he was wrong on some points of physics, that was because he was a man, and it is not given to a single man, nor to a single century, to know all.

We rise to the knowledge of the truth, like those giants who climbed up to the skies by standing on the shoulders of one another.* The Huygenses,† and the Leibnizes learned from Descartes and Galileo, these great men who, so far, are known to you only by name, and with whose works I hope soon to make you acquainted. It is by making the most of the works of Kepler, and using the theorems of Huygens, that M. Newton discovered this universal force spread throughout nature, which makes the planets circle around the Sun, and that operates as gravity on Earth. . . .

Today the systems of Descartes and Newton divide the thinking world, so you should know the one and the other; but so many learned men have taken care to expound and to correct Descartes' system that it will be easy for you to learn from their works. One of my aims in the first part of this work is to put before your eyes the other part of this great process, to make you acquainted with the system of M. Newton, to show you how far making connections and determining probability are pushed, and how the phenomena are explained by the hypothesis of attraction. . . .

Guard yourself, my son, whichever side you take in this dispute among the philosophers, against the inevitable obstinacy to which the spirit of partisanship carries one: this frame of mind is dangerous on all occasions of life; but it is ridiculous in physics. The search for truth is the only thing in which the love of your country must not prevail, and it is surely very unfortunate that the opinions of Newton and of Descartes have become a sort of national affair. About a book of physics one must ask if it is good, not if the author is English, German, or French."

*Here, Madame du Châtelet echoes the famous statement of Newton from a 1676 letter to Robert Hooke, an English scientist.

†Christiaan Huygens (1629–1695) was a Dutch astronomer, physicist, and mathematician who observed the correct shape of the rings of Saturn and patented the first pendulum clock.

EVALUATE THE EVIDENCE

1. How does Madame du Châtelet explain progress in the physical sciences? What guidance does she offer her son in choosing between Descartes and Newton?
2. What support does this passage provide for the "international" character of the Scientific Revolution? Does this passage suggest any commonalities between the Scientific Revolution and the Enlightenment?

Source: Emilie Du Châtelet, *Selected Philosophical and Scientific Writings*, ed. Judith P. Zinsser, trans. Isabelle Bour and Judith P. Zinsser, pp. 118–120. Copyright © 1992 by Cambridge University Press. All rights reserved. Used by permission of University of Chicago Press.

who set the universe in motion and then ceased to intervene in human affairs. Above all, Voltaire and most of the philosophes hated all forms of religious intolerance, which they believed led to fanaticism. Simple piety and human kindness—as embodied in Christ's commandments to "love God and your neighbor as yourself"—were religion enough.

The ultimate strength of the philosophes lay in their dedication and organization. The philosophes felt keenly that they were engaged in a common undertaking that transcended individuals. Their greatest and most representative intellectual achievement was, quite fittingly, a group effort—the seventeen-volume *Encyclopedia: The Rational Dictionary of the Sciences, the Arts, and the Crafts*, edited by Denis Diderot (DEE-duh-roh) (1713–1784) and Jean le Rond d'Alembert (dah-luhm-BEHR) (1717–1783). From different circles and with different interests, the two men set out to find coauthors who would examine the rapidly expanding whole of human knowledge. Even more fundamentally, they set out to teach people how to think critically and objectively about all matters. As Diderot said, he wanted the *Encyclopedia* to "change the general way of thinking."[9]

The *Encyclopedia* survived initial resistance from the French government and the Catholic Church. Published between 1751 and 1772, it contained seventy-two thousand articles by leading scientists, writers, skilled workers, and progressive priests, and it treated every aspect of life and knowledge. Not every article was daring or original, but the overall effect was little short of revolutionary. Science and the industrial arts were exalted, religion and immortality questioned. Intolerance, legal injustice, and out-of-date social institutions were openly criticized. The encyclopedists were convinced that greater knowledge would result in greater human happiness, for knowledge was useful and made possible economic, social, and political progress. Summing up the new worldview of the Enlightenment, the *Encyclopedia* was widely read, especially in less-expensive reprint editions, and it was extremely influential.

Jean-Jacques Rousseau

In the early 1740s Jean-Jacques Rousseau (1712–1778), the son of a poor Swiss watchmaker, made his way into the Parisian Enlightenment through his brilliant intellect. He contributed articles on music to the *Encyclopedia* and became friends with its editors. Appealing but neurotic, Rousseau came to believe that the philosophes were plotting against him. In the mid-1750s he broke with them, living thereafter as a lonely outsider with his uneducated common-law wife and going in his own highly original direction.

Like other Enlightenment thinkers, Rousseau was passionately committed to individual freedom. Unlike them, however, he attacked rationalism and civilization as destroying, rather than liberating, the individual. Warm, spontaneous feeling had to complement and correct cold intellect. Moreover, the basic goodness of the individual and the unspoiled child had to be protected from the cruel refinements of civilization. Rousseau's ideals greatly influenced the early romantic movement, which rebelled against the culture of the Enlightenment in the late eighteenth century.

Rousseau also called for a rigid division of gender roles. According to Rousseau, women and men were radically different beings. Destined by nature to assume a passive role in sexual relations, women should also be subordinate in social life. Women's love for displaying themselves in public, attending social gatherings, and pulling the strings of power was unnatural and had a corrupting effect on both politics and society. Rousseau thus rejected the sophisticated way of life of Parisian elite women. His criticism led to calls for privileged women to renounce their frivolous ways and stay at home to care for their children.

Rousseau's contribution to political theory in *The Social Contract* (1762) was based on two fundamental concepts: the general will and popular sovereignty. According to Rousseau, the general will is sacred and absolute, reflecting the common interests of all the people, who have displaced the monarch as the holder of sovereign power. The general will is not necessarily the will of the majority, however. At times the general will may be the authentic, long-term needs of the people as correctly interpreted by a farsighted minority. Little noticed in its day, Rousseau's concept of the general will had a great impact on the political aspirations of the American and French Revolutions. Rousseau was both one of the most influential voices of the Enlightenment and, in his rejection of rationalism and social discourse, a harbinger of reaction against Enlightenment ideas.

The International Enlightenment

The Enlightenment was a movement of international dimensions, with thinkers traversing borders in a constant exchange of visits, letters, and printed materials. Voltaire alone wrote almost eighteen thousand letters to correspondents in France and across Europe. The Republic of Letters was a truly cosmopolitan set of networks stretching from western Europe to its colonies in the Americas, to Russia and eastern Europe, and along the routes of trade and empire to Africa and Asia.

Within this broad international conversation, scholars have identified regional and national particularities. Outside of France, many strains of Enlightenment—Protestant, Catholic, and Jewish—sought to reconcile reason with faith, rather than emphasizing the errors of religious fanaticism and intolerance. Some scholars point to a distinctive "Catholic Enlightenment" that aimed to renew and reform the church from within, looking to divine grace rather than human will as the source of progress.

The Scottish Enlightenment, which was centered in Edinburgh, was marked by an emphasis on common sense and scientific reasoning. After the Act of Union with England in 1707, Scotland was freed from political crisis to experience a vigorous period of intellectual growth. Scottish intellectual revival was also stimulated by the creation of the first public educational system in Europe.

A central figure in Edinburgh was David Hume (1711–1776), whose emphasis on civic morality and religious skepticism had a powerful impact at home and abroad. Building on Locke's teachings on learning, Hume argued that the human mind is really nothing but a bundle of impressions. These impressions originate only in sensory experiences and our habits of

joining these experiences together. Since our ideas ultimately reflect only our sensory experiences, our reason cannot tell us anything about questions that cannot be verified by sensory experience (in the form of controlled experiments or mathematics), such as the origin of the universe or the existence of God. Paradoxically, Hume's rationalistic inquiry ended up undermining the Enlightenment's faith in the power of reason.

Another major figure of the Scottish Enlightenment was Adam Smith. His *Theory of Moral Sentiments* (1759) argued that the thriving commercial life of the eighteenth century produced civic virtue through the values of competition, fair play, and individual autonomy. In *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776), Smith attacked the laws and regulations that, he argued, prevented commerce from reaching its full capacity (see Chapter 17).

The Enlightenment in British North America was heavily influenced by English and Scottish thinkers, especially John Locke, and by Montesquieu's arguments for checks and balances in government. Leaders of the American Enlightenment, including Benjamin Franklin and Thomas Jefferson, would play a leading role in the American Revolution (see Chapter 19).

After 1760 Enlightenment ideas were hotly debated in the German-speaking states, often in dialogue with Christian theology. Immanuel Kant (1724–1804), a professor in East Prussia, was the greatest German philosopher of his day. Kant posed the question of the age when he published a pamphlet in 1784 entitled *What Is Enlightenment?* He answered, "*Sapere Aude* [dare to know]! 'Have the courage to use your own understanding' is therefore the motto of enlightenment." He argued that if intellectuals were granted the freedom to exercise their reason publicly in print, enlightenment would almost surely follow. Kant was no revolutionary; he also insisted that in their private lives, individuals must obey all laws, no matter how unreasonable, and should be punished for "impertinent" criticism. Like other Enlightenment figures in central and east-central Europe, Kant thus tried to reconcile absolute monarchical authority and religious faith with a critical public sphere.

Major Figures of the Enlightenment

Baruch Spinoza (1632–1677)	Early Enlightenment thinker excommunicated from the Jewish religion for his concept of a deterministic universe
John Locke (1632–1704)	*Essay Concerning Human Understanding* (1690)
Gottfried Wilhelm von Leibniz (1646–1716)	German philosopher and mathematician known for his optimistic view of the universe
Pierre Bayle (1647–1706)	*Historical and Critical Dictionary* (1697)
Montesquieu (1689–1755)	*The Persian Letters* (1721); *The Spirit of Laws* (1748)
Voltaire (1694–1778)	Renowned French philosophe and author of more than seventy works
David Hume (1711–1776)	Central figure of the Scottish Enlightenment; *Of Natural Characters* (1748)
Jean-Jacques Rousseau (1712–1778)	*The Social Contract* (1762)
Denis Diderot (1713–1784) and Jean le Rond d'Alembert (1717–1783)	Editors of *Encyclopedia: The Rational Dictionary of the Sciences, the Arts, and the Crafts* (1751–1772)
Adam Smith (1723–1790)	*The Theory of Moral Sentiments* (1759); *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776)
Immanuel Kant (1724–1804)	*What Is Enlightenment?* (1784); *On the Different Races of Man* (1775)
Moses Mendelssohn (1729–1786)	Major philosopher of the Haskalah, or Jewish Enlightenment
Cesare Beccaria (1738–1794)	*On Crimes and Punishments* (1764)

Northern Europeans often regarded the Italian states as culturally backward, yet important developments in Enlightenment thought took place in the Italian peninsula. After achieving independence from Habsburg rule (1734), the kingdom of Naples entered a period of intellectual expansion as reformers struggled to lift the heavy weight of church and noble power. In northern Italy a central figure was Cesare Beccaria (1738–1794), a nobleman educated at Jesuit schools and the University of Pavia. His *On Crimes and Punishments* (1764) was a passionate plea for reform of the penal system that decried the use of torture, arbitrary imprisonment, and capital punishment, and advocated the prevention of crime over the reliance on punishment. The text was quickly translated into French and English and made an impact throughout Europe.

Urban Culture and Life in the Public Sphere

Enlightenment ideas did not float on thin air. A series of new institutions and practices encouraged the spread of enlightened ideas in the late seventeenth and eighteenth centuries. First, the European production and consumption of books grew significantly. In Germany, for example, the number of new titles appearing annually rose from roughly six hundred in 1700 to twenty-six hundred in 1780. Moreover, the types of books people read changed dramatically. The proportion of religious and devotional books published in Paris declined after 1750; history and law held constant; the arts and sciences surged.

reading revolution The transition in Europe from a society where literacy consisted of patriarchal and communal reading of religious texts to a society where literacy was commonplace and reading material was broad and diverse.

salon Regular social gathering held by talented and rich Parisians in their homes, where philosophes and their followers met to discuss literature, science, and philosophy.

Reading more books on many more subjects, the educated public approached reading in a new way. The result was what some scholars have called a **reading revolution**. The old style of reading in Europe had been centered on a core of sacred texts that taught earthly duty and obedience to God. Reading had been patriarchal and communal, with the father slowly reading the text aloud to his assembled family. Now reading involved a broader field of books that constantly changed. Reading became individual and silent, and texts could be questioned. Subtle but profound, the reading revolution ushered in new ways of relating to the written word.

Conversation, discussion, and debate also played a critical role in the Enlightenment. Evolving from the gatherings presided over by the *précieuses* in the late seventeenth century (see Chapter 15), the **salon** was a regular meeting held in the elegant private drawing rooms (or salons) of talented, wealthy men and women. There they encouraged the exchange of witty observations on literature, science, and philosophy among great aristocrats, wealthy middle-class finan-

The French Book Trade Book consumption surged in the eighteenth century and, along with it, new bookstores. This appealing bookshop in France with its intriguing ads for the latest works offers to put customers "Under the Protection of Minerva," the Roman goddess of wisdom. Large packets of books sit ready for shipment to foreign countries. (akg-images/De Agostini Picture Library)

Enlightenment Culture

An actor performs the first reading of a new play by Voltaire at the salon of Madame Geoffrin. Voltaire, then in exile, is represented by a bust statue.

(Académie des Sciences, Belles-Lettres, Rouen, France/Giraudon/The Bridgeman Art Library)

EVALUATE THE EVIDENCE

1. Which of these people do you think is the hostess, Madame Geoffrin, and why? Using details from the painting to support your answer, how would you describe the status of the people shown?
2. What does this image suggest about the reach of Enlightenment ideas to common people? To women? Does the painting of the bookstore on page 522 suggest a broader reach? Why?

ciers, high-ranking officials, and noteworthy foreigners. Many of the most celebrated salons were hosted by women, known as *salonnières* (sah-lahn-ee-EHRZ), such as Madame du Deffand, whose weekly Parisian salon included such guests as Montesquieu, d'Alembert, and Benjamin Franklin, then serving as the first U.S. ambassador to France. Invitations to salons were highly coveted; introductions to the rich and powerful could make the career of an ambitious writer, and, in turn, the social elite found amusement and cultural prestige in their ties to up-and-coming artists and men of letters. (See "Primary Source 16.4: Enlightenment Culture," above.)

The salon thus represented an accommodation between the ruling classes and the leaders of Enlightenment thought. Salons were sites in which the philosophes, the French nobility, and the prosperous middle classes intermingled and influenced one another while maintaining due deference to social rank. Critical thought about almost any question became fashionable and flourished alongside hopes for human progress through greater knowledge and enlightened public opinion.

Elite women also exercised great influence on artistic taste. Soft pastels, ornate interiors, sentimental portraits, and starry-eyed lovers protected by hovering cupids were all hallmarks of the style they favored. This style, known as **rococo** (ruh-KOH-koh), was popular throughout Europe in the period from 1720 to 1780. It has been argued that feminine influence in the drawing room went hand in hand with the emergence of polite society and the general attempt to civilize a rough military nobility. Similarly, some philosophes championed greater rights and expanded education for women, claiming that the position and treatment of women were the best indicators of a society's level of civilization and decency.[10] For these male philosophes, greater rights for women did not mean equal rights, and the philosophes were not particularly disturbed by the fact that elite women remained legally subordinate to men in economic and political affairs. Elite women lacked many rights, but so did the majority of European men, who were poor.

rococo A popular style in Europe in the eighteenth century, known for its soft pastels, ornate interiors, sentimental portraits, and starry-eyed lovers protected by hovering cupids.

public sphere An idealized intellectual space that emerged in Europe during the Enlightenment, where the public came together to discuss important issues relating to society, economics, and politics.

While membership at the salons was restricted to the well-born, the well connected, and the exceptionally talented, a number of institutions provided the rest of society with access to Enlightenment ideas. Lending libraries served an important function for people who could not afford their own books. The coffeehouses that first appeared in the late seventeenth century became meccas of philosophical discussion. (See "Living in the Past: Coffeehouse Culture," page 526.) In addition to these institutions, book clubs, debating societies, Masonic lodges (groups of Freemasons, a secret society that accepted craftsmen and shopkeepers as well as middle-class men and nobles), and newspapers all played roles in the creation of a new **public sphere** that celebrated open debate informed by critical reason. The public sphere was an idealized space where members of society came together as individuals to discuss issues relevant to the society, economics, and politics of the day.

What of the common people? Did they participate in the Enlightenment? Enlightenment philosophes did not direct their message to peasants or urban laborers. They believed that the masses had no time or talent for philosophical speculation and that elevating them would be a long and potentially dangerous process. Deluded by superstitions and driven by violent passions, the people, they thought, were like children in need of firm parental guidance. D'Alembert characteristically made a sharp distinction between "the truly enlightened public" and "the blind and noisy multitude."[11] Despite these prejudices, the ideas of the philosophes did find an audience among some members of the common people. At a time of rising literacy, book prices were dropping and many philosophical ideas were popularized in cheap pamphlets and through public reading. Although they were barred from salons and academies, ordinary people were not immune to the new ideas in circulation.

Race and the Enlightenment

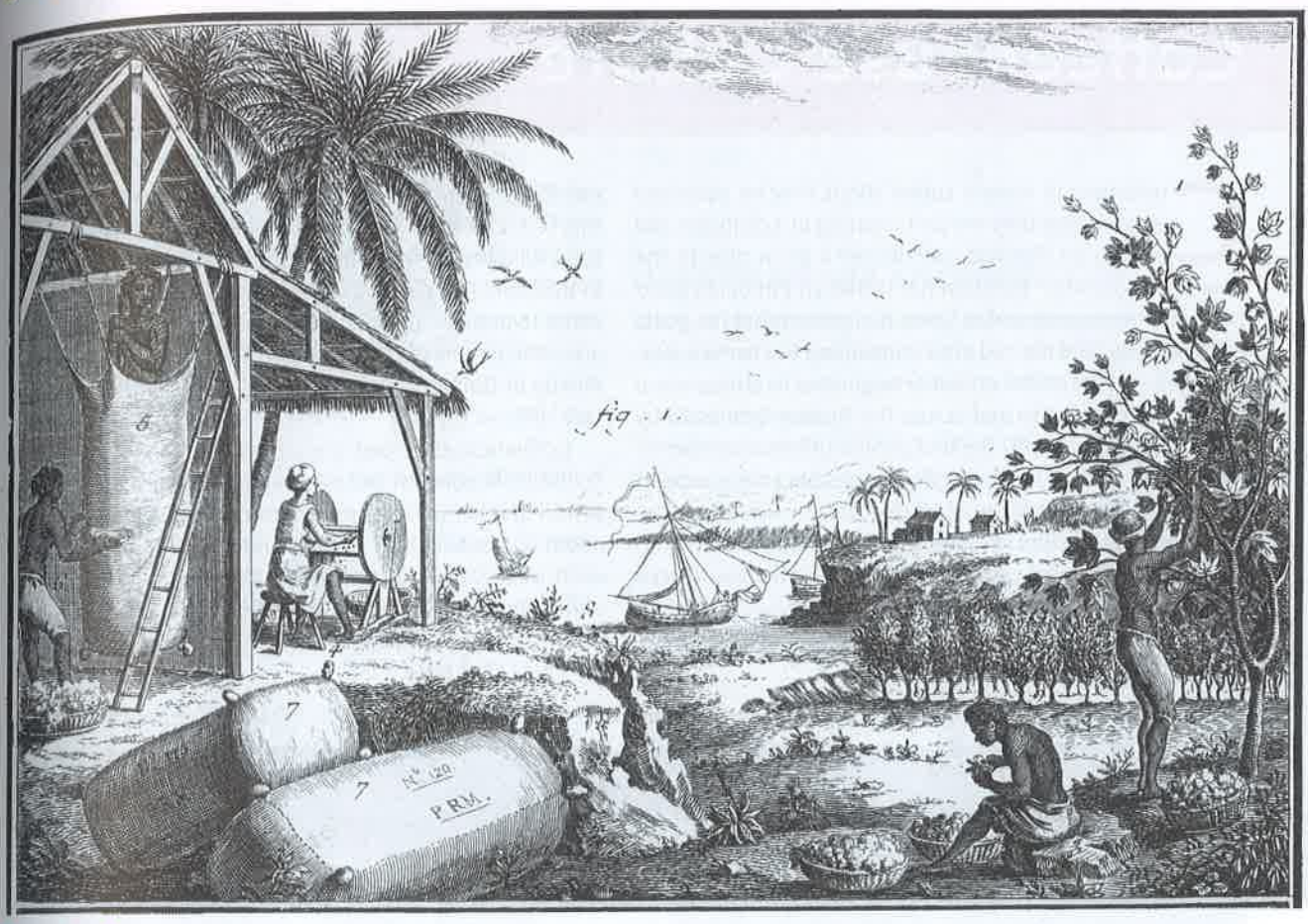
If philosophers did not believe the lower classes qualified for enlightenment, how did they regard individuals of different races? In recent years, historians have found in the Scientific Revolution and the Enlightenment a crucial turning point in European ideas about race. A primary catalyst for new ideas about race was the urge to classify nature unleashed by the Scientific Revolution's insistence on careful empirical observation. In *The System of Nature* (1735), Swedish botanist Carl von Linné argued that nature was organized into a God-given hierarchy. As scientists developed taxonomies of plant and animal species, they also began to classify humans into hierarchically ordered "races" and to investigate the origins of race. The comte de Buffon (komt duh buh-FOHN) argued that humans originated with one species that then developed into distinct races due largely to climatic conditions.

Enlightenment thinkers such as David Hume and Immanuel Kant helped popularize these ideas. In *Of Natural Characters* (1748), Hume wrote:

> I am apt to suspect the negroes and in general all other species of men (for there are four or five different kinds) to be naturally inferior to the whites. There never was a civilized nation of any other complexion than white, nor even any individual eminent amongst them, no arts, no sciences. . . . Such a uniform and constant difference could not happen, in so many countries and ages if nature had not made an original distinction between these breeds of men.[12]

Kant taught and wrote as much about "anthropology" and "geography" as he did about standard philosophical themes such as logic, metaphysics, and moral philosophy. He elaborated his views about race in *On the Different Races of Man* (1775), claiming that there were four human races, each of which had derived from an original race. According to Kant, the closest descendants of the original race were the white inhabitants of northern Germany. (Scientists now believe the human race originated in Africa.)

Using the word *race* to designate biologically distinct groups of humans, akin to distinct animal spe-



Encyclopedia Image of the Cotton Industry This romanticized image of slavery in the West Indies cotton industry was published in Diderot and d'Alembert's *Encyclopedia*. It shows enslaved men, at right, gathering and picking over cotton bolls, while the woman at left mills the bolls to remove their seeds. The *Encyclopedia* presented mixed views on slavery; one article described it as "indispensable" to economic development, while others argued passionately for the natural right to freedom of all mankind. (Courtesy, Dover Publications)

cies, was new. Previously, Europeans grouped other peoples into "nations" based on their historical, political, and cultural affiliations, rather than on supposedly innate physical differences. Unsurprisingly, when European thinkers drew up a hierarchical classification of human species, their own "race" was placed at the top. Europeans had long believed they were culturally superior to "barbaric" peoples in Africa and, since 1492, the New World. Now emerging ideas about racial difference taught them they were biologically superior as well. In turn, scientific racism helped legitimate and justify the tremendous growth of slavery that occurred during the eighteenth century. If one "race" of humans was fundamentally different and inferior, its members could be seen as particularly fit for enslavement and liable to benefit from tutelage by the superior race.

Racist ideas did not go unchallenged. The abbé Raynal's *History of the Two Indies* (1770) fiercely attacked slavery and the abuses of European colonization. *Encyclopedia* editor Denis Diderot adopted Montesquieu's technique of criticizing European attitudes through the voice of outsiders in his dialogue between Tahitian villagers and their European visitors. (See "Primary Source 16.5: Denis Diderot, 'Supplement to Bougainville's Voyage,'" page 528.) Scottish philosopher James Beattie (1735–1803) responded directly to claims of white superiority by pointing out that Europeans had started out as savage as nonwhites supposedly were and that many non-European peoples in the Americas, Asia, and Africa had achieved high levels of civilization. Former slaves, like Olaudah Equiano (see Chapter 17) and Ottobah Cugoana, published eloquent memoirs testifying to the horrors of slavery and the innate equality of all humans. These challenges to racism, however, were in the minority. Many other Enlightenment voices supporting racial inequality—Thomas Jefferson among them—may be found.

Scholars are only at the beginning of efforts to understand the links between Enlightenment thinkers'

LIVING IN THE PAST
Coffeehouse Culture

Customers in today's coffee shops may be surprised to learn that they are participating in a centuries-old institution that has contributed a great deal to the idea of "modernity." Tradition has it that an Ethiopian goatherd first discovered coffee when he noticed that his goats became frisky and danced after consuming the berries. Botanists agree that coffee probably originated in Ethiopia and then spread to Yemen and across the Arabian peninsula by around 1000 C.E. In 1457 the first public coffeehouse opened in Istanbul, and from there coffeehouses became a popular institution throughout the Muslim world.

European travelers in Istanbul were astonished at its inhabitants' passion for coffee, which one described as "blacke as soote, and tasting not much unlike it."* However, Italian merchants introduced coffee to Europe around 1600, and the first European coffee shop opened in Venice in 1645, soon followed by shops in Oxford, England, in 1650, London in 1652, and Paris in 1672. By the 1730s coffee shops had become so popular in London that one observer noted, "There are some people of moderate Fortunes, that lead their Lives mostly in Coffee-Houses, they eat, drink and sleep (in the Day-time) in them."†

Coffeehouses helped spread the ideas and values of the Scientific Revolution and the Enlightenment. They provided a new public space where urban Europeans could learn about and debate the issues of the day. Within a few years, each political party, philosophical sect, scientific society, and literary circle had its own coffeehouse, which served as

Seventeenth-century English coffeehouse. (The Granger Collection, NY)

*Quoted in Markman Ellis, *The Coffee House: A Cultural History* (London: Phoenix, 2004), p. 8.

†Quoted ibid, p. 198.

a central gathering point for its members and an informal recruiting site for new ones. Coffeehouses self-consciously distinguished themselves from the rowdy atmosphere of the tavern; whereas alcohol dulled the senses, coffee sharpened the mind for discussion.

European coffeehouses also played a key role in the development of modern business, as their proprietors began to provide specialized commercial news to attract customers. Lloyd's of London, the famous insurance company, got its start in the shipping lists published by coffeehouse owner Edward Lloyd in the 1690s. The streets around London's stock exchange were crowded with coffeehouses where merchants and traders congregated to strike deals and hear the latest news.

Coffeehouses succeeded in Europe because they met a need common to politics, business, and intellectual life: the spread and sharing of information. In the late seventeenth century newspapers were rare and expensive, there were few banks to guarantee credit, and politics was limited to a tiny elite. To break through these constraints, people needed reliable information. The coffeehouse was an ideal place to acquire it, along with a new kind of stimulant that provided the energy and attention to fuel a lively discussion.

QUESTIONS FOR ANALYSIS

1. What do the images shown here suggest about the customers of eighteenth-century coffeehouses? Who frequented these establishments? Who was excluded?
2. What limitations on the exchange of information existed in early modern Europe? Why were coffeehouses so useful as sites for exchanging information?
3. What social role do coffeehouses play where you live? Do you see any continuities with the eighteenth-century coffeehouse?

Eighteenth-century Viennese coffeehouse. (Erich Lessing/Art Resource, NY)

PRIMARY SOURCE 16.5

Denis Diderot, "Supplement to Bougainville's Voyage"

Denis Diderot was born in a provincial town in eastern France and educated in Paris. Rejecting careers in the church and the law, he devoted himself to literature and philosophy. In 1749, sixty years before Charles Darwin's birth, Diderot was jailed by Parisian authorities for publishing an essay questioning God's role in creation and suggesting the autonomous evolution of species. Following these difficult beginnings, Diderot's editorial work and writing on the Encyclopedia *were the crowning intellectual achievements of his life and, according to some, of the Enlightenment itself.*

Like other philosophes, Diderot employed numerous genres to disseminate Enlightenment thought, ranging from scholarly articles in the Encyclopedia *to philosophical treatises, novels, plays, book reviews, and erotic stories. His "Supplement to Bougainville's Voyage" (1772) was a fictional account of a European voyage to Tahiti inspired by the writings of traveler Louis-Antoine de Bougainville. In this passage, Diderot expresses his own loathing of colonial conquest and exploitation through the voice of an elderly Tahitian man. The character's praise for his own culture allows Diderot to express his Enlightenment idealization of "natural man," free from the vices of civilized societies.*

He was the father of a large family. When the Europeans arrived he looked upon them with scorn, showing neither astonishment, nor fear, nor curiosity. On their approach he turned his back and retired into his hut. Yet his silence and anxiety revealed his thoughts only too well; he was inwardly lamenting the eclipse of his countrymen's happiness. When Bougainville was leaving the island, as the natives swarmed on the shore, clutching his clothes, clasping his companions in their arms and weeping, the old man made his way forward and proclaimed solemnly, "Weep, wretched natives of Tahiti, weep. But let it be for the coming and not the leaving of these ambitious, wicked men. One day you will know them better. One day they will come back, bearing in one hand the piece of wood you see in that man's belt, and, in the other, the sword hanging by the side of that one, to enslave you, slaughter you, or make you captive to their follies and vices. One day you will be subject to them, as corrupt, vile and miserable as they are. . . ."

Then turning to Bougainville, he continued, "And you, leader of the ruffians who obey you, pull your ship away swiftly from these shores. We are innocent, we are content, and you can only spoil that happiness. We follow the pure instincts of nature, and you have tried to erase its impression from our hearts. Here, everything belongs to everyone, and you have preached I can't tell what distinction between 'yours' and 'mine'. . . . If a Tahitian should one day land on your shores and engrave on one of your stones or on the bark of one of your trees, *This land belongs to the people of Tahiti*, what would you think then? You are stronger than we are, and what does that mean? When one of the miserable trinkets with which your ship is filled was taken away, what an uproar you made, what revenge you exacted! At that moment, in the depths of your heart, you were plotting the theft of an entire country! You are not a slave, you would rather die than be one, and yet you wish to make slaves of us. Do you suppose, then, that a Tahitian cannot defend his own liberty and die for it as well? This inhabitant of Tahiti, whom you wish to ensnare like an animal, is your brother. You are both children of Nature. What right do you have over him that he does not have over you? You came; did we attack you? Have we plundered your ship? Did we seize you and expose you to the arrows of our enemies? Did we harness you to work with our animals in the fields? We respected our own image in you.

"Leave us our ways; they are wiser and more decent than yours. We have no wish to exchange what you call our ignorance for your useless knowledge. Everything that we need and is good for us we already possess. Do we merit contempt because we have not learnt how to acquire superfluous needs? When we are hungry, we have enough to eat. When we are cold, we have enough to wear. You have entered our huts; what do you suppose we lack? Pursue as far as you wish what you call the comforts of life, but let sensible beings stop when they have no more to gain from their labours than imaginary benefits. If you persuade us to go beyond the strict bounds of necessity, when will we finish our work?

When will we enjoy ourselves? We have kept our annual and daily labours within the smallest possible limits, because in our eyes nothing is better than rest. Go back to your own country to agitate and torment yourselves as much as you like. But leave us in peace. Do not fill our heads with your factitious needs and illusory virtues. . . ."

EVALUATE THE EVIDENCE

1. On what grounds does the speaker argue for the Tahitians' basic equality with the Europeans?
2. What is the good life according to the speaker, and how does it contrast with the European way of life? Which do you think is the better path?
3. In what ways could Diderot's thoughts here be seen as representative of Enlightenment ideas? Are there ways in which they are not?
4. How realistic do you think this account is? How might defenders of expansion respond?

Source: Edited excerpts from pp. 41–43 in Denis Diderot, *Political Writings*, translated and edited by John Hope Mason and Robert Wokler. Copyright © 1992 by Cambridge University Press. Reprinted by permission of Cambridge University Press.

ideas about race and their notions of equality, progress, and reason. There are clear parallels, though, between the use of science to propagate racial hierarchies and its use to defend social inequalities between men and women. French philosopher Jean-Jacques Rousseau used women's "natural" passivity to argue for their subordinate role in society, just as other thinkers used non-Europeans' "natural" inferiority to defend slavery and colonial domination. The new powers of science and reason were thus marshaled to imbue traditional stereotypes with the force of natural law.

Enlightened Absolutism

What impact did new ways of thinking have on political developments and monarchical absolutism?

How did the Enlightenment influence political developments? To this important question there is no easy answer. Most Enlightenment thinkers outside of England and the Netherlands, especially in central and eastern Europe, believed that political change could best come from above—from the ruler—rather than from below. Royal absolutism was a fact of life, and the monarchs of Europe's leading states clearly had no intention of giving up their great power. Therefore, the philosophes and their sympathizers realistically concluded that a benevolent absolutism offered the best opportunities for improving society.

Many government officials were interested in philosophical ideas. They were among the best-educated members of society, and their daily involvement in complex affairs of state made them naturally attracted to ideas for improving human society. Encouraged and instructed by these officials, some absolutist rulers tried to reform their governments in accordance with Enlightenment ideals—what historians have called the **enlightened absolutism** of the later eighteenth century. In both Catholic and Protestant lands, rulers typically fused Enlightenment principles with religion, drawing support for their innovations from reform-minded religious thinkers. The most influential of the new-style monarchs were in Prussia, Russia, and Austria, and their example illustrates both the achievements and the great limitations of enlightened absolutism. France experienced its own brand of enlightened absolutism in

enlightened absolutism Term coined by historians to describe the rule of eighteenth-century monarchs who, without renouncing their own absolute authority, adopted Enlightenment ideals of rationalism, progress, and tolerance.

the contentious decades prior to the French Revolution (see Chapter 19).

Frederick the Great of Prussia

Frederick II (r. 1740–1786), commonly known as Frederick the Great, built masterfully on the work of his father, Frederick William I (see Chapter 15). Although in his youth he embraced culture and literature rather than the militarism championed by his father, by the time he came to the throne Frederick was determined to use the splendid army he had inherited.

Therefore, when the young empress Maria Theresa of Austria inherited the Habsburg dominions upon the death of her father Charles VI, Frederick pounced. He invaded her rich province of Silesia (sigh-LEE-zhuh), defying solemn Prussian promises to respect the Pragmatic Sanction, a diplomatic agreement that had guaranteed Maria Theresa's succession. In 1742, as other greedy powers vied for her lands in the European War of the Austrian Succession (1740–1748), Maria Theresa was forced to cede almost all of Silesia to Prussia. In one stroke Prussia had doubled its population to 6 million people. Now Prussia unquestionably stood as a European Great Power.

The War of the Austrian Succession, 1740–1748

Though successful in 1742, Frederick had to fight against great odds to save Prussia from total destruction after the ongoing competition between Britain and France for colonial empire brought another great conflict in 1756. Maria Theresa, seeking to regain Silesia, formed an alliance with the leaders of France and Russia. The aim of the alliance during the resulting Seven Years' War (1756–1763) was to conquer Prussia and divide up its territory. Despite invasions from all sides, Frederick fought on with stoic courage. In the end he was miraculously saved: Peter III came to the Russian throne in 1762 and called off the attack against Frederick, whom he greatly admired.

cameralism View that monarchy was the best form of government, that all elements of society should serve the monarch, and that, in turn, the state should use its resources and authority to increase the public good.

The terrible struggle of the Seven Years' War tempered Frederick's interest in territorial expansion and brought him to consider how more humane policies for his subjects might also strengthen the state. Thus Frederick went beyond a superficial commitment to Enlightenment culture for himself and his circle. He tolerantly allowed his subjects to believe as they wished in religious and philosophical matters. He promoted the advancement of knowledge, improving his country's schools and permitting scholars to publish their findings. Moreover, Frederick tried to improve the lives of his subjects more directly. As he wrote to his friend Voltaire, "I must enlighten my people, cultivate their manners and morals, and make them as happy as human beings can be, or as happy as the means at my disposal permit."

The legal system and the bureaucracy were Frederick's primary tools. Prussia's laws were simplified, torture was abolished, and judges decided cases quickly and impartially. Prussian officials became famous for their hard work and honesty. After the Seven Years' War ended in 1763, Frederick's government energetically promoted the reconstruction of agriculture and industry. Frederick himself set a good example. He worked hard and lived modestly, claiming that he was "only the first servant of the state." Thus Frederick justified monarchy in terms of practical results and said nothing of the divine right of kings.

Frederick's dedication to high-minded government went only so far, however. While he condemned serfdom in the abstract, he accepted it in practice and did not free the serfs on his own estates. He accepted and extended the privileges of the nobility, who remained the backbone of the army and the entire Prussian state.

In reforming Prussia's bureaucracy, Frederick drew on the principles of **cameralism**, the German science of public administration that emerged in the decades following the Thirty Years' War. Influential throughout the German lands, cameralism held that monarchy was the best of all forms of government, that all elements of society should be placed at the service of the state, and that, in turn, the state should make use of its resources and authority to improve society. Predating the Enlightenment, cameralist interest in the public good was usually inspired by the needs of war. Cameralism shared with the Enlightenment an emphasis on rationality, progress, and utilitarianism.

Catherine the Great of Russia

Catherine the Great of Russia (r. 1762–1796) was one of the most remarkable rulers of her age, and the French

Catherine the Great Strongly influenced by the Enlightenment, Catherine the Great cultivated the French philosophes and instituted moderate reforms, only to reverse them in the aftermath of Pugachev's rebellion. This equestrian portrait now hangs above her throne in the palace throne room in St. Petersburg. (Musée des Beaux-Arts, Chartres/The Bridgeman Art Library)

philosophes adored her. Catherine was a German princess from Anhalt-Zerbst, an insignificant principality sandwiched between Prussia and Saxony. Her father commanded a regiment of the Prussian army, but her mother was related to the Romanovs of Russia, and that proved to be Catherine's opening to power.

Catherine's Romanov connection made her a suitable bride at the age of fifteen for the heir to the Russian throne. It was a mismatch from the beginning, but her *Memoirs* made her ambitions clear: "I did not care about Peter, but I did care about the crown." When her husband, Peter III, came to power during the Seven Years' War, his decision to withdraw Russian troops from the coalition against Prussia alienated the army. Catherine profited from his unpopularity to form a conspiracy to depose her husband. In 1762 Catherine's lover Gregory Orlov and his three brothers, all army officers, murdered Peter, and the German princess became empress of Russia.

Catherine had drunk deeply at the Enlightenment well. Never questioning that absolute monarchy was the best form of government, she set out to rule in an enlightened manner. She had three main goals. First, she worked hard to continue Peter the Great's effort to bring the culture of western Europe to Russia (see Chapter 15). To do so, she imported Western architects, musicians, and intellectuals. She bought masterpieces of Western art and patronized the philosophes. An enthusiastic letter writer, she corresponded extensively with Voltaire and praised him as the "champion of the human race." When the French government banned the *Encyclopedia*, she offered to publish it in St. Petersburg, and she sent money to Diderot when he needed it. With these actions, Catherine won good press in the West for herself and for her country. Moreover, this intellectual ruler, who wrote plays and loved good talk, set the tone for the entire Russian nobility. Peter the Great westernized Russian armies, but it was Catherine who westernized the imagination of the Russian nobility.

Catherine's second goal was domestic reform, and she began her reign with sincere and ambitious projects.

MAPPING THE PAST

Map 16.1 The Partition of Poland, 1772–1795

In 1772 war between Russia and Austria threatened over Russian gains from the Ottoman Empire. To satisfy desires for expansion without fighting, Prussia's Frederick the Great proposed that parts of Poland be divided among Austria, Prussia, and Russia. In 1793 and 1795 the three powers partitioned the remainder, and the republic of Poland ceased to exist.

ANALYZING THE MAP Of the three powers that divided the kingdom of Poland, which gained the most territory? How did the partition affect the geographical boundaries of each state, and what was the significance? What border with the former Poland remained unchanged? Why do you think this was the case?

CONNECTIONS What does it say about European politics at the time that a country could simply cease to exist on the map? Could that happen today?

In 1767 she appointed a legislative commission to prepare a new law code. This project was never completed, but Catherine did restrict the practice of torture and allowed limited religious toleration. She also tried to improve education and strengthen local government. The philosophes applauded these measures and hoped more would follow.

Such was not the case. In 1773 a common Cossack soldier named Emelian Pugachev sparked a gigantic uprising of serfs, very much as Stenka Razin had done a century earlier (see Chapter 15). Proclaiming himself the true tsar, Pugachev issued orders abolishing serfdom, taxes, and army service. Thousands joined his cause, slaughtering landlords and officials over a vast area of southwestern Russia. Pugachev's untrained forces eventually proved no match for Catherine's noble-led army. Betrayed by his own company, Pugachev was captured and savagely executed.

Pugachev's rebellion put an end to any intentions Catherine had about reforming the system. The peasants were clearly dangerous, and her empire rested on the support of the nobility. After 1775 Catherine gave the nobles absolute control of their serfs, and she extended serfdom into new areas, such as Ukraine. In 1785 she freed nobles forever from taxes and state service. Under Catherine the Russian nobility attained its most exalted position, and serfdom entered its most oppressive phase.

Catherine's third goal was territorial expansion, and in this respect she was extremely successful. Her armies subjugated the last descendants of the Mongols and the Crimean Tartars, and began the conquest of the Caucasus (KAW-kuh-suhs). Her greatest coup by far was the partition of Poland (Map 16.1). When, between 1768 and 1772, Catherine's armies scored unprecedented victories against the Ottomans and thereby threatened to disturb the balance of power between Russia and Austria in eastern Europe, Frederick of Prussia obligingly came forward with a deal. He proposed that Turkey be let off easily and that Prussia, Austria, and Russia each compensate itself by taking a gigantic slice of the weakly ruled Polish territory. Catherine jumped at the chance. The first partition of Poland took place in 1772. Subsequent partitions in 1793 and 1795 gave away the rest of Polish territory, and the ancient republic of Poland vanished from the map.

The Austrian Habsburgs

Another female monarch, Maria Theresa (r. 1740–1780) of Austria, set out to reform her nation, although traditional power politics was a more important motivation for her than were Enlightenment teachings. A devoutly Catholic mother and wife who inherited power from her father, Charles VI, Maria Theresa was a remarkable but old-fashioned absolutist. Her more radical son, Joseph II (r. 1780–1790), drew on Enlightenment ideals, earning the title of "revolutionary emperor."

Emerging from the long War of the Austrian Succession in 1748 with the serious loss of Silesia, Maria Theresa was determined to introduce reforms that would make the state stronger and more efficient. First, she initiated church reform, with measures aimed at limiting the papacy's influence, eliminating many religious holidays, and reducing the number of monasteries. Second, a whole series of administrative renovations strengthened the central bureaucracy, smoothed out some provincial differences, and revamped the tax system, taxing even the lands of nobles, previously exempt from taxation. Third, the government sought to improve the lot of the agricultural population, cautiously reducing the power of lords over their hereditary serfs and their partially free peasant tenants.

Coregent with his mother from 1765 onward and a strong supporter of change from above, Joseph II moved forward rapidly when he came to the throne in 1780. Most notably, Joseph abolished serfdom in 1781, and in 1789 he decreed that peasants could pay landlords in cash rather than through labor on their land. This measure was violently rejected not only by the nobility but also by the peasants it was intended to help, because they lacked the necessary cash. When a disillusioned Joseph died prematurely at forty-nine, the entire Habsburg empire was in turmoil. His brother Leopold II (r. 1790–1792) canceled Joseph's radical edicts in order to re-establish order. Peasants once again were required to do forced labor for their lords.

Despite differences in their policies, Joseph II and the other absolutists of the later eighteenth century combined old-fashioned state-building with the culture and critical thinking of the Enlightenment. In doing so, they succeeded in expanding the role of the state in the life of society. They perfected bureaucratic machines that were to prove surprisingly adaptive and enduring. Their failure to implement policies we would recognize as humane and enlightened—such as abolishing serfdom—may reveal inherent limitations in Enlightenment thinking about equality and social justice, rather than deficiencies in their execution of Enlightenment programs. The fact that leading philosophes supported rather than criticized eastern rulers' policies exposes the blind spots of the era.

Jewish Life and the Limits of Enlightened Absolutism

Perhaps the best example of the limitations of enlightened absolutism are the debates surrounding the emancipation of the Jews. Europe's small Jewish

INDIVIDUALS IN SOCIETY

Moses Mendelssohn and the Jewish Enlightenment

In 1743 a small, humpbacked Jewish boy with a stammer left his poor parents in Dessau in central Germany and walked eighty miles to Berlin, the capital of Frederick the Great's Prussia. According to one story, when the boy reached the Rosenthaler (ROH-zuhn-taw-lehr) Gate, the only one through which Jews could pass, he told the inquiring watchman that his name was Moses and that he had come to Berlin "to learn." The watchman laughed and waved him through. "Go Moses, the sea has opened before you."*

In Berlin the young Mendelssohn studied Jewish law and eked out a living copying Hebrew manuscripts in a beautiful hand. But he was soon fascinated by an intellectual world that had been closed to him in the Dessau ghetto. There, like most Jews throughout central Europe, he had spoken Yiddish—a mixture of German, Polish, and Hebrew. Now, working mainly on his own, he mastered German; learned Latin, Greek, French, and English; and studied mathematics and Enlightenment philosophy. Word of his exceptional abilities spread in Berlin's Jewish community (the dwelling of 1,500 of the city's 100,000 inhabitants). He began tutoring the children of a wealthy Jewish silk merchant, and he soon became the merchant's clerk and later his partner. But his great passion remained the life of the mind and the spirit, which he avidly pursued in his off-hours.

Lavater (right) attempts to convert Mendelssohn, in a painting by Moritz Oppenheim of an imaginary encounter. (akg-images)

Gentle and unassuming in his personal life, Mendelssohn was a bold thinker. Reading eagerly in Western philosophy since antiquity, he was, as a pious Jew, soon convinced that Enlightenment teachings need not be opposed to Jewish thought and religion. He concluded that reason could complement and strengthen religion, although each would retain its integrity as a separate sphere.† Developing his idea in his first great work, *On the Immortality of the Soul* (1767), Mendelssohn

*H. Kupferberg, *The Mendelssohns: Three Generations of Genius* (New York: Charles Scribner's Sons, 1972), p. 3.

†David Sorkin, *Moses Mendelssohn and the Religious Enlightenment* (Berkeley: University of California Press, 1996), pp. 8ff.

ONLINE DOCUMENT ASSIGNMENT

How did Moses Mendelssohn fit into the larger Enlightenment debate about religious tolerance?

Go to the Integrated Media and examine primary sources written by Mendelssohn and his contemporaries, and then complete a writing assignment based on the evidence and details from this chapter.

used the neutral setting of a philosophical dialogue between Socrates and his followers in ancient Greece to argue that the human soul lived forever. In refusing to bring religion and critical thinking into conflict, he was strongly influenced by contemporary German philosophers who argued similarly on behalf of Christianity. He reflected the way the German Enlightenment generally supported established religion, in contrast to the French Enlightenment, which attacked it.

Mendelssohn's treatise on the human soul captivated the educated German public, which marveled that a Jew could have written a philosophical masterpiece. In the excitement, a Christian zealot named Lavater challenged Mendelssohn in a pamphlet to accept Christianity or to demonstrate how the Christian faith was not "reasonable." Replying politely but passionately, the Jewish philosopher affirmed that his studies had only strengthened him in his faith, although he did not seek to convert anyone not born into Judaism. Rather, he urged toleration in religious matters and spoke up courageously against Jewish oppression.

Orthodox Jew and German philosophe, Moses Mendelssohn serenely combined two very different worlds. He built a bridge from the ghetto to the dominant culture over which many Jews would pass, including his novelist daughter Dorothea and his famous grandson, the composer Felix Mendelssohn.

QUESTIONS FOR ANALYSIS

1. How did Mendelssohn seek to influence Jewish religious thought in his time?
2. How do Mendelssohn's ideas compare with those of the French Enlightenment?

populations lived under highly discriminatory laws. For the most part, Jews were confined to tiny, overcrowded ghettos, were excluded by law from most professions, and could be ordered out of a kingdom at a moment's notice. Still, a very few did manage to succeed and to obtain the right of permanent settlement, usually by performing some special service for the state. Many rulers relied on Jewish bankers for loans to raise armies and run their kingdoms. Jewish merchants prospered in international trade because they could rely on contacts with colleagues in Jewish communities scattered across Europe.

The Pale of Settlement, 1791

In the eighteenth century an Enlightenment movement known as the **Haskalah** emerged from within the European Jewish community, led by the Prussian philosopher Moses Mendelssohn (1729–1786). (See "Individuals in Society: Moses Mendelssohn and the Jewish Enlightenment," at left.) Christian and Jewish Enlightenment philosophers, including Mendelssohn, began to advocate for freedom and civil rights for European Jews. In an era of reason and progress, they argued, restrictions on religious grounds could not stand. The Haskalah accompanied a period of controversial social change within Jewish communities, in which rabbinic controls loosened and heightened interaction with Christians took place.

Haskalah The Jewish Enlightenment of the second half of the eighteenth century, led by the Prussian philosopher Moses Mendelssohn.

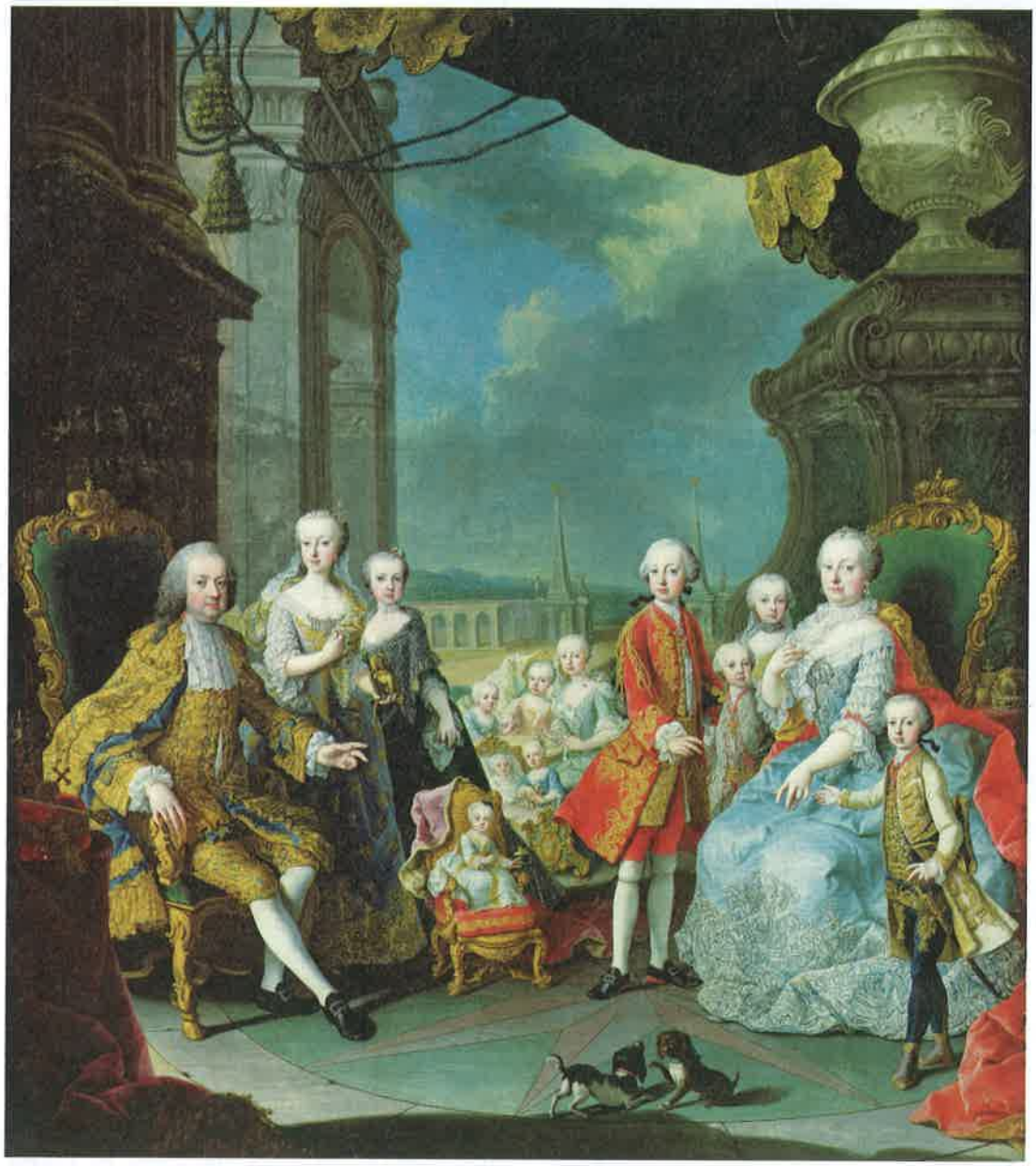
Arguments for tolerance won some ground. The British Parliament passed a law allowing naturalization of Jews in 1753, but later repealed the law due to public outrage. The most progressive reforms took place under Austrian emperor Joseph II. Among his liberal edicts of the 1780s were measures intended to integrate Jews more fully into society, including eligibility for military service, admission to higher education and artisanal trades, and removal of requirements for special clothing or emblems. Welcomed by many Jews, these reforms raised fears among traditionalists of assimilation into the general population.

Many monarchs rejected all ideas of emancipation. Although he permitted freedom of religion to his Christian subjects, Frederick the Great of Prussia firmly opposed any general emancipation for the Jews, as he did for the serfs. Catherine the Great, who acquired most of Poland's large Jewish population when

she annexed part of that country in the late eighteenth century, similarly refused. In 1791 she established the Pale of Settlement, a territory including parts of modern-day Poland, Latvia, Lithuania, Ukraine, and Belarus, in which most Jews were required to live. Jewish habitation was restricted to the Pale until the Russian Revolution in 1917.

The first European state to remove all restrictions on the Jews was France under the French Revolution. Over the next hundred years, Jews gradually won full legal and civil rights throughout the rest of western Europe. Emancipation in eastern Europe took even longer and aroused more conflict and violence.

Maria Theresa The empress (see page 533) and her husband pose with twelve of their sixteen children at Schönbrunn palace in this family portrait by court painter Martin Meytens (1695–1770). Joseph, the heir to the throne, stands at the center of the star on the floor. Wealthy women often had very large families, in part because they, unlike poor women, seldom nursed their babies. (Château de Versailles, France, The Bridgeman Art Library)



Notes

1. Quoted in Butterfield, *The Origins of Modern Science*, p. 47.
2. Ibid., p. 120.
3. Quoted in John Freely, *Aladdin's Lamp: How Greek Science Came to Europe Through the Islamic World* (New York: Knopf, 2009), p. 206.
4. Ibid., p. 217.
5. Ibid., p. 225.
6. Jacqueline Broad, *Women Philosophers of the Seventeenth Century* (Cambridge, U.K.: Cambridge University Press, 2003), p. 17.
7. L. Schiebinger, *The Mind Has No Sex? Women in the Origins of Modern Science* (Cambridge, Mass.: Harvard University Press, 1989), p. 64.
8. Quoted in G. L. Mosse et al., eds., *Europe in Review* (Chicago: Rand McNally, 1964), p. 156.
9. Quoted in P. Gay, "The Unity of the Enlightenment," *History* 3 (1960): 25.
10. See E. Fox-Genovese, "Women in the Enlightenment," in *Becoming Visible: Women in European History*, 2d ed., ed. R. Bridenthal, C. Koonz, and S. Stuard (Boston: Houghton Mifflin, 1987), esp. pp. 252–259, 263–265.
11. Jean Le Rond d'Alembert, *Eloges lus dans les séances publiques de l'Académie française* (Paris, 1779), p. ix, quoted in Mona Ozouf, "'Public Opinion' at the End of the Old Regime," *The Journal of Modern History* 60, *Supplement: Rethinking French Politics in 1788* (September 1988): S9.
12. Quoted in Emmanuel Chukwudi Eze, ed., *Race and the Enlightenment: A Reader* (Oxford: Blackwell, 1997), p. 33.

LOOKING BACK LOOKING AHEAD

Hailed as the origin of modern thought, the Scientific Revolution must also be seen as a product of its past. Medieval universities gave rise to important new scholarship, and the ambition and wealth of Renaissance patrons nurtured intellectual curiosity. Religious faith also influenced the Scientific Revolution, inspiring thinkers to understand the glory of God's creation, while bringing censure and personal tragedy to others. Natural philosophers following Copernicus pioneered new methods of observing and explaining nature while drawing on centuries-old traditions of mysticism, astrology, alchemy, and magic.

The Enlightenment ideas of the eighteenth century were a similar blend of past and present; they could serve as much to bolster absolutist monarchical regimes as to inspire revolutionaries to fight for individual rights and liberties. Although the Enlightenment fostered critical thinking about everything from science to religion, the majority of Europeans, including many prominent thinkers, remained devout Christians.

The achievements of the Scientific Revolution and the Enlightenment are undeniable. Key Western values of rationalism, human rights, and open-mindedness were born from these movements. With their new notions of progress and social improvement, Europeans would embark on important revolutions in industry and politics in the centuries that followed. Nonetheless, others have seen a darker side. For these critics, the mastery over nature permitted by the Scientific Revolution now threatens to overwhelm the earth's fragile equilibrium, and the Enlightenment belief in the universal application of reason can lead to arrogance and intolerance of other people's spiritual, cultural, and political values. Such vivid debates about the legacy of these intellectual and scientific developments testify to their continuing importance in today's world.

REVIEW and EXPLORE

MAKE IT STICK

LearningCurve
After reading the chapter, go online and use LearningCurve to retain what you've read.

Identify Key Terms

Identify and explain the significance of each item below.

natural philosophy (p. 504)
Copernican hypothesis (p. 506)
experimental method (p. 508)
law of inertia (p. 508)
law of universal gravitation (p. 510)
empiricism (p. 511)
Cartesian dualism (p. 512)
Enlightenment (p. 516)
rationalism (p. 516)
philosophes (p. 517)
reading revolution (p. 522)
salon (p. 522)
rococo (p. 524)
public sphere (p. 524)
enlightened absolutism (p. 529)
cameralism (p. 530)
Haskalah (p. 535)

Review the Main Ideas

Answer the focus questions from each section of the chapter.

- What revolutionary discoveries were made in the sixteenth and seventeenth centuries? (p. 504)
- What intellectual and social changes occurred as a result of the Scientific Revolution? (p. 511)
- What new ideas about society and human relations emerged in the Enlightenment, and what new practices and institutions enabled these ideas to take hold? (p. 516)
- What impact did new ways of thinking have on political developments and monarchical absolutism? (p. 529)

Make Connections

Think about the larger developments and continuities within and across chapters.

1. How did the era of European exploration and discovery (Chapter 14) impact the ideas of scientists and philosophers discussed in this chapter? In what ways did contact with new peoples and places stimulate new forms of thought among Europeans?
2. What was the relationship between the Scientific Revolution and the Enlightenment? How did new ways of understanding the natural world influence thinking about human society?
3. Compare the policies and actions of seventeenth-century absolutist rulers (Chapter 15) with their "enlightened" descendants described in this chapter. How accurate is the term *Enlightened absolutism*?

ONLINE DOCUMENT ASSIGNMENT
Moses Mendelssohn

How did Moses Mendelssohn fit into the larger Enlightenment debate about religious tolerance?

You encountered Moses Mendelssohn's story on page 534. Keeping the question above in mind, go to the Integrated Media and examine primary sources from Mendelssohn's time—including a letter to a contemporary, an excerpt from a play, and a philosophical treatise. Then complete a writing assignment based on the evidence and details from this chapter.

Suggested Reading and Media Resources

BOOKS

- Dear, Peter. *Revolutionizing the Sciences: European Knowledge and Its Ambitions, 1500–1700,* 2d ed. 2009. An accessible and well-illustrated introduction to the Scientific Revolution.
- Delbourgo, James, and Nicholas Dew, eds. *Science and Empire in the Atlantic World.* 2008. A collection of essays examining the relationship between the Scientific Revolution and the imperial expansion of European powers across the Atlantic.
- Ellis, Markman. *The Coffee House: A Cultural History.* 2004. An engaging study of the rise of the coffeehouse and its impact on European cultural and social life.
- Eze, Emmanuel Chukwudi, ed. *Race and the Enlightenment: A Reader.* 1997. A pioneering source on the origins of modern racial thinking in the Enlightenment.
- Liebersohn, Harry. *The Travelers' World: Europe to the Pacific.* 2008. A beautifully written account of Europeans' voyages to the Pacific and the impact of these voyages on Enlightenment ideas.
- Massie, Robert K. *Catherine the Great: Portrait of a Woman.* 2012. Recounts the life story of Catherine from obscure German princess to enlightened ruler of Russia.
- McMahon, Darrin M. *Happiness: A History.* 2006. Discusses how worldly pleasure became valued as a duty of individuals and societies in the Enlightenment.
- Messbarger, Rebecca. *The Lady Anatomist: The Life and Work of Anna Morandi Manzolini.* 2010. The life of an Italian woman artist and scientist who showed the opportunities and constraints for eighteenth-century women.
- Outram, Dorinda. *The Enlightenment,* 2d ed. 2006. An outstanding and accessible introduction to Enlightenment debates that emphasizes the Enlightenment's social context and global reach.
- Robertson, John. *The Case for the Enlightenment: Scotland and Naples, 1680–1760.* 2005. A comparative study of Enlightenment movements in Scotland and Naples, emphasizing commonalities between these two small kingdoms on the edges of Europe.
- Shapin, Steven. *The Scientific Revolution.* 2001. A concise and well-informed general introduction to the Scientific Revolution.
- Sorkin, David. *Moses Mendelssohn and the Religious Enlightenment.* 1996. A brilliant study of the Jewish philosopher and of the role of religion in the Enlightenment.

DOCUMENTARIES

- *Galileo's Battle for the Heavens* (PBS, 2002). Recounts the story of Galileo's struggle with the Catholic Church over his astronomical discoveries, featuring re-enactments of key episodes in his life.
- *Newton's Dark Secrets* (PBS, 2005). Explores Isaac Newton's fundamental scientific discoveries alongside his religious faith and practice of alchemy.

FEATURE FILMS AND TELEVISION

- *Catherine the Great* (A&E, 1995). A made-for-television movie starring Catherine Zeta-Jones as the German princess who becomes Catherine the Great.
- *Dangerous Liaisons* (Stephen Frears, 1988). Based on a 1782 novel, the story of two aristocrats who cynically manipulate others, until one of them falls in love with a chaste widow chosen as his victim.
- *Longitude* (A&E, 2000). A television miniseries that follows the parallel stories of an eighteenth-century clockmaker striving to find a means to measure longitude at sea and a modern-day veteran who restores the earlier man's clocks.
- *Ridicule* (Patrice Leconte, 1996). When a provincial nobleman travels to the French court in the 1780s to present a project to drain a malarial swamp in his district, his naïve Enlightenment ideals incur the ridicule of decadent courtiers.

WEB SITES

- *The Encyclopedia of Diderot & d'Alembert Collaborative Translation Project.* A collaborative project to translate the *Encyclopedia* edited by Denis Diderot and Jean le Rond d'Alembert into English, with searchable entries submitted by students and scholars and vetted by experts.
  quod.lib.umich.edu/d/did/
- *The Hermitage Museum.* The Web site of the Russian Hermitage Museum founded by Catherine the Great in the Winter Palace in St. Petersburg, with virtual tours of the museum's rich collections.
  www.hermitagemuseum.org/html_En/index.html
- *Mapping the Republic of Letters.* A site hosted by Stanford University showcasing projects using mapping software to create spatial visualizations based on correspondence and travel of members of the eighteenth-century Republic of Letters.
  republicofletters.stanford.edu/