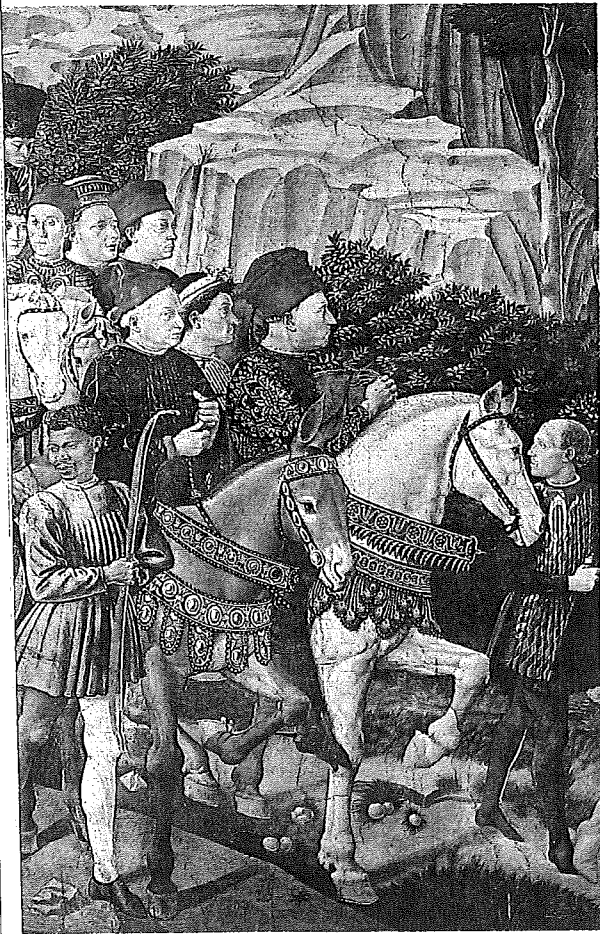


8

The Renaissance and Reformation

(1350–1600)



A procession of the Medici, the leading family of Renaissance Florence, with their servants and followers.

Chapter Outline

- 1 Spirit of the Renaissance
- 2 Art and Literature of the Renaissance
- 3 Changing Patterns of Life
- 4 Beginnings of the Protestant Reformation
- 5 Further Challenges to the Catholic Church

In Florence, Italy, the Guasconti family was sitting down to dinner when a young man burst into the room. He drew a knife and threw himself at one of the startled diners, crying: "Traitors, this is the day on which I mean to murder you all!" When none of the terror-stricken family dared offer battle, the man changed his mind. He ran down the stairs, only to find a dozen other members of the Guasconti household, armed with shovels, iron pipes, and clubs.

Later, the young man recalled, "When I got among them, raging like a mad bull, I flung four or five to the earth, and fell down with them myself, continually aiming my dagger now at one and now at another." Incredibly, when the dust settled, no one was hurt, and the man ran off down the street.

The young fighter was Benvenuto Cellini (chehl LEE nee), a talented goldsmith and sculptor who lived from 1500 to 1571. Cellini led an amazingly turbulent and full life, which he described in his *Autobiography*. He explained in the book that he had fought with the Guasconti because they questioned his skill as a goldsmith.

Cellini was proud of his many talents. He played the flute, wrote elegant poetry, and was a clever diplomat. His drive and determination knew no bounds. When Rome was besieged by a neighboring city-state, Cellini stood at a crucial castle post, firing artillery at the advancing enemy. In his *Autobiography*, he boasted, "It was I who saved the castle."

Cellini was just one of many gifted personalities whose bold achievements proclaimed a new age. These individuals left a lasting mark on the European scene during the period from 1350 to 1600, known as the Renaissance.

Renaissance is a French word meaning rebirth. During the Renaissance, scholars reacted against what they saw as the "dark ages" of medieval Europe and revived the learning of ancient Greece and Rome. They thought they were bringing about the rebirth of civilization.

The Renaissance was both a worldly and a religious age. Great achievements in the arts and sciences were combined with deep religious concerns. In fact, during the Renaissance, fierce debates over questions of faith and salvation sparked the Reformation, a movement that divided Christians in Europe into many different groups. By 1600, Europeans had left behind the world of the Middle Ages and had established the foundations for modern Europe.

1 Spirit of the Renaissance

During the 1300s, economic distress, war, and the Black Death had swept across Western Europe. As Western Europe recovered from these disasters, a new creative spirit emerged. This spirit was at the heart of the Renaissance. The Renaissance began first in the *city-states* of northern Italy. Later, it spread to northern Europe.

The Italian City-States

The political and economic situation in northern Italy provided fertile ground for the Renaissance. During the Middle Ages, many Italian towns had expanded into city-states. Each city-state governed itself and the surrounding countryside. Such independence left the rulers of the city-states free to experiment in government as well as in the larger world of ideas.

By the late Middle Ages, Italian city-states had grown wealthy from trade and industry. Merchants from Venice, Genoa, and Pisa controlled the most profitable trade routes to the eastern Mediterranean. Other cities, such as Florence, thrived on the sale of manufactured goods, especially wool cloth. In addition, Italian bankers made large profits by financing commercial ventures and making loans to princes and popes. The wealth of the city-states supported the Renaissance.

Merchants and bankers made up a powerful middle class in the Italian city-states.

■ The Renaissance spirit flourished in the northern Italian city-states. The major city-states are shown on this map, but there were dozens of smaller city-states, all in competition with one another. Ambitious rulers frequently went to war against their neighbors, making northern Italy the center of endless intrigues.



Political and economic leadership fell to this class rather than to landowning nobles because feudalism had never fully developed in northern Italy.

The concerns of the wealthy middle class helped shape the Renaissance in Italy. For example, the Renaissance reflected their concern for education and individual achievement. Furthermore, they had the time and money to become patrons, or supporters, of the arts.

Florence was typical of the Italian city-states in some ways. During the 1400s, a single powerful family, the Medici (MEHD ih chee), ruled Florence. Giovanni de' Medici had organized a bank in Florence in 1397. Over the next 30 years, the bank flourished, and the family opened offices as far away as London. Giovanni's son, Cosimo, and then his great-grandson, Lorenzo, controlled the government of Florence. The Medici and their supporters frequently clashed with other leading families in an atmosphere of intrigue and treachery. Yet under the Medici, Florence came to symbolize the creative spirit of the Renaissance.

Like many Renaissance rulers, the Medici were well-educated and had many interests. For example, Lorenzo, known as "the

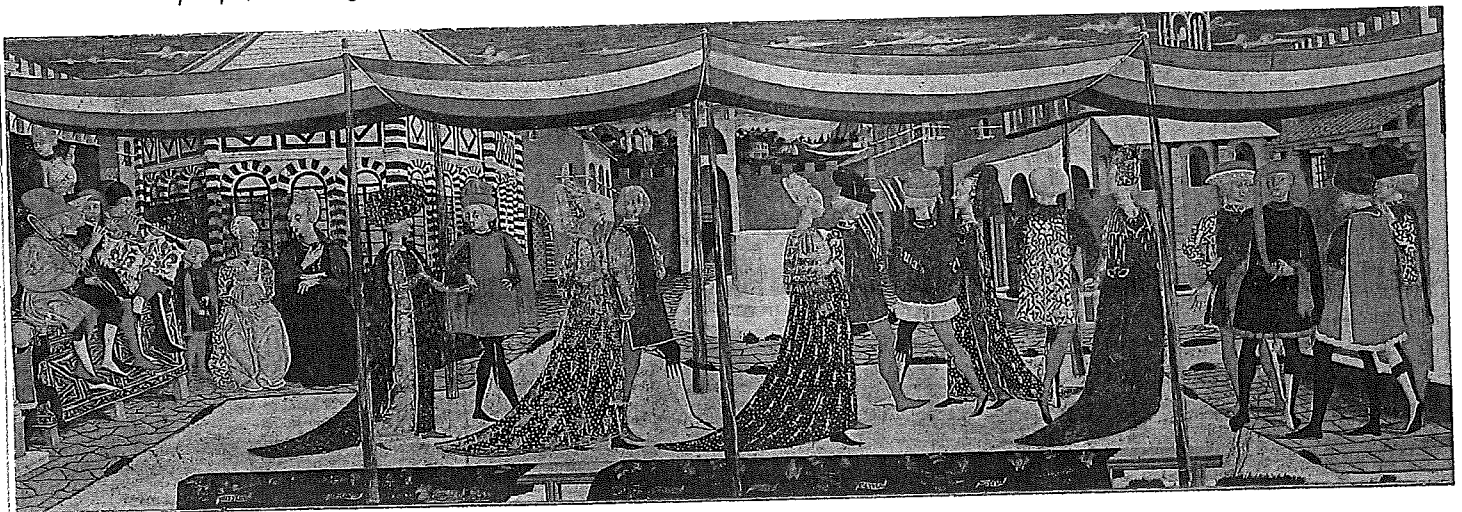
Magnificent," was a skilled architect. The Medici were proud of Florence and wanted all citizens to share their pride. They used part of the Medici fortune to hire local painters, sculptors, architects, and silversmiths to create works of art to beautify Florence. Many artists felt that as true artists they should be actively involved in the life of their city, not withdrawn from the everyday world.

Study of the Humanities

People in the Italian city-states developed a renewed interest in education, especially in the learning of ancient Greece and Rome. At the universities, theology, law, and medicine were traditionally the most highly respected subjects. However, during the Renaissance, scholars also stressed the *studia humanitatis*, the study of the humanities. The humanities included the subjects taught in ancient Greek and Roman schools—grammar, rhetoric, poetry, and history. Renaissance scholars who studied those subjects were called humanists.

Renaissance humanists were practical people. They wanted to learn more about the world. By reading ancient texts, they rediscovered knowledge that had been lost or for-

In the Italian city-states, rulers lived in great luxury. At the courts of these Renaissance rulers, good manners, loyalty, wit, and piety were considered essential. This painting shows a wedding procession in Florence. Notice the rich clothes of the people attending the wedding.



gotten during the Middle Ages. Many were closely involved in the political and economic life of their age. Many Renaissance humanists were also devout Christians. They felt that the study of the humanities enriched their lives as Christians because it went beyond the dry, abstract works of medieval scholars.

Renaissance scholars thought education was the way to become a well-rounded individual. Only with a proper education, they argued, could a person enjoy a full, rewarding life. One scholar advised a student:

I beg you, take care. Add a little every day and gather things in. Remember that these studies promise you enormous prizes both in the conduct of your life and the fame and glory of your name . . . acquaint yourself with what pertains to life and manners—those things that are called humane studies because they perfect and adorn man.

This philosophy reflected the Renaissance confidence in individual abilities.

Recovering the Classics

Francesco Petrarch (PEE trahrk) was an early Renaissance humanist from Florence who lived from 1304 to 1374. Petrarch traveled about Europe in search of old manuscripts. He especially prized the works of the Roman statesman Cicero and the early Christian writer St. Augustine. Medieval scholars had studied the writings of both men, but Petrarch uncovered new evidence about the times when Cicero and St. Augustine had lived. During his research, Petrarch began to realize how much of the classical heritage had been lost.

Petrarch's work encouraged others to try to recover writings of the classical world. They searched for ancient manuscripts in monastery libraries. Often, the conditions they found shocked them. A visitor to one monastery library discovered that only the walls remained standing. There was no door or roof. A thick layer of dust covered everything, and grass grew on the window sills. The manuscripts lay in disorganized piles.

While searching for classical texts, Renaissance humanists rescued many hidden

treasures. They wanted to restore the classics they found to their original form. Therefore, they compared copies of the same work to discover where mistakes had been made when it was recopied.

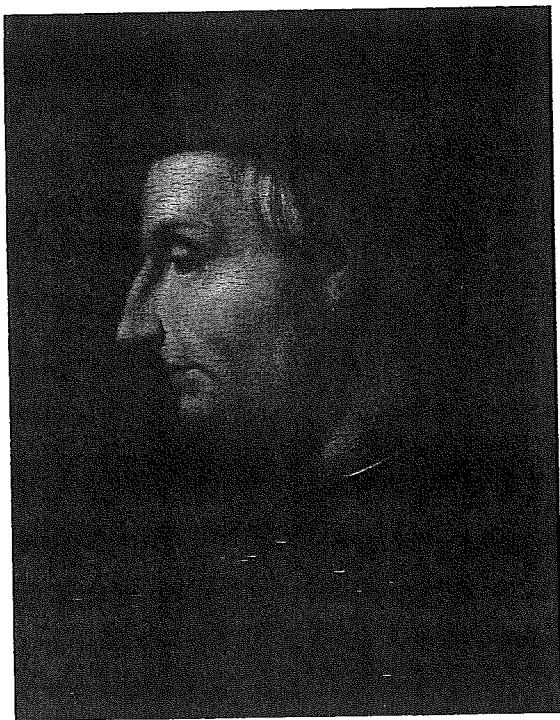
Scholars also tried to learn when ancient manuscripts were written. To do so, they developed sophisticated techniques for analyzing historical documents. One scholar, Lorenzo Valla, examined the Donation of Constantine, a document in which the emperor Constantine supposedly gave the pope control over Rome and the Western Roman Empire. By careful analysis, Valla exposed the document as a forgery. For example, he pointed out that it contained the term "fief," which was unknown in Constantine's time. This search for knowledge carried Renaissance thinkers such as Valla into dangerous areas because their work questioned long-held assumptions about the accuracy of ancient writings.

Handbooks for Proper Behavior

Renaissance writers often prepared manuals that told individuals how to behave. One well-known manual was *The Prince* by Niccolò Machiavelli (MAHK ee uh VEHL ee). Machiavelli wrote *The Prince* as a handbook for rulers of the Italian city-states, who often faced unstable political conditions. Within a city, different factions, or groups, constantly struggled for power. In addition, city-states were frequently at war with one another.

In *The Prince*, Machiavelli recommended that a ruler adopt a realistic course of action in order to stay in power. If a ruler could afford to be benevolent, that was fine. But Machiavelli cautioned, "It is much safer to be feared than to be loved, if one must choose." He taught that "the end justifies the means"—that is, a ruler should employ any methods to achieve his goal. He advised rulers to use a mixture of cunning, diplomacy, and ruthlessness.

Another influential manual was *The Book of the Courtier* by Baldassare Castiglione (KAHS tee LYOH neh). Castiglione described the qualities that a courtier, or refined, educated aristocrat, should possess.



Niccolò Machiavelli, a diplomat and government official in Florence, dedicated *The Prince* to Lorenzo de' Medici. The advice Machiavelli gave on how a ruler can stay in power is often considered ruthless and cynical. A typical piece of advice was: "If all men were good, this advice would not be good, but since men are wicked and do not keep their promises to you, you likewise do not have to keep yours to them."

He praised the study of the humanities and urged courtiers to cultivate their talents. They should learn to appreciate music and play a variety of instruments. They should also be able to speak gracefully and provide rulers with witty, pleasant company. In short, Castiglione drew a picture of what he considered an ideal Renaissance person, someone who had a broad education in many different areas.

The Renaissance in Northern Europe

The Renaissance blossomed first in the Italian city-states, where commerce and a wealthy middle class supported learning and

the arts. Renaissance ideas spread slowly northward.

In northern Europe and Spain, the Renaissance took a different form. For one thing, feudalism, with its traditions of knighthood and chivalry, was stronger in northern Europe than in Italy. Therefore, kings, queens, and nobles, rather than merchants and bankers, were the chief patrons of the arts.

Furthermore, Renaissance scholars in northern Europe and Spain took a more traditional approach to religion than some Italian humanists. They studied classical works, but they were more likely to study the writings of early Christians than of Greeks and Romans. Northern European humanists devoted their time to uncovering what they believed was the simpler, purer faith of the early Christians.

Despite differences between the Renaissance in Italy and the Renaissance in the rest of Europe, Renaissance artists, writers, and scholars pursued similar goals. They stressed individual achievement and classical learning. Furthermore, they stimulated a vigorous creative spirit that revolutionized thinking in Western Europe. Compared to people in the Middle Ages, people during the Renaissance were more concerned with achieving worldly success. Yet they maintained a strong faith in Christianity.

SECTION REVIEW

1. Identify: Lorenzo de' Medici, Francesco Petrarch, Niccolò Machiavelli, Baldassare Castiglione.
 2. How did the wealth of the Italian city-states encourage the Renaissance spirit?
 3. (a) What subjects made up the humanities?
(b) According to Renaissance scholars, what was the purpose of education?
 4. How did scholars try to find errors in ancient manuscripts?
 5. What advice did Machiavelli give to rulers?
 6. According to Castiglione, what was the ideal Renaissance person?
 7. Describe one way in which the Renaissance in northern Europe differed from the Renaissance in Italy.
-

2 Art and Literature of the Renaissance

The Renaissance spirit came vividly to life in literature and the arts. Writers produced a huge outpouring of literature, which both shaped and reflected Renaissance ideas. Artists, especially painters and sculptors, found an important place in the Renaissance world.

During the Middle Ages, painters and sculptors decorated many churches and cathedrals, but they received little individual recognition for their work. As a result, the names of only a few medieval artists are known today. In contrast, dozens of Renaissance artists are well known today. Popes, rulers, merchants, and bankers competed for their services. Renaissance artists proudly accepted the fame that their creative genius brought.

Classical Influence

During the Renaissance, artists returned to the classical principles of Greek and Roman art. The Greeks stressed harmony and balance in nature, and the Romans emphasized realism.

Renaissance artists in Italy found inspiration in ancient Roman buildings scattered across the land. In the early 1400s, the sculptor Donatello (DAHN uh TEHL oh) and the architect Filippo Brunelleschi (BROO nehl LEHS kee) traveled from Florence to Rome. There, they sketched the ruins of ancient buildings as well as ancient marble and bronze statues.

The visit to Rome produced dramatic results. When Donatello returned to Florence, he created a statue of David, a king of the ancient Hebrews. The statue was unlike medieval sculptures, in which individual figures appeared as part of a larger work on tombs or cathedral walls. Like ancient Greek and Roman statues, Donatello's David stood alone, free to be admired from all sides. Furthermore, it portrayed David with realism and grace.

Brunelleschi and other Renaissance architects rejected medieval Gothic architecture and revived classical styles. They designed elegant buildings, using columns and domes. Brunelleschi created a sensation when he proposed to top the unfinished cathedral of Florence with a vast dome. Many people thought the building would collapse. But Brunelleschi had studied ancient Roman buildings, and he overcame the technical problems involved in raising the dome.

Years later, when the artist and architect Michelangelo Buonarroti (mī k'ī AHN juh LOH BWOH nahr ROH tee) designed Saint Peter's Cathedral in Rome, he designed the dome using the engineering principles developed by Brunelleschi.

New Techniques in Art

Many Renaissance artists tried to show the world realistically, as it actually existed. Early in the Renaissance, the Florentine artist Giotto (JAHT oh) used shadings of dark and light to add a feeling of space to his paintings. Later, the painter Tommaso Masaccio (mah SAHT choh) and Brunelleschi developed rules of perspective to give paintings an even more realistic look. The rules of perspective enabled artists to paint scenes so that they appeared to be three dimensional. For example, to give a sense of depth or distance in a scene, figures closer to the viewer were drawn larger. Those further off were drawn smaller.

Artists in Flanders* made significant contributions to Renaissance art by improving paints. Medieval artists had worked with tempera paints. In tempera paints, the pigments, or colors, were mixed with watered-down egg yolk. Tempera paints dried quickly, so artists could not make changes

* Flanders included parts of what is today Belgium and the Netherlands. People from Flanders were called Flemish.

once they had applied the color. Furthermore, tempera paints did not blend easily.

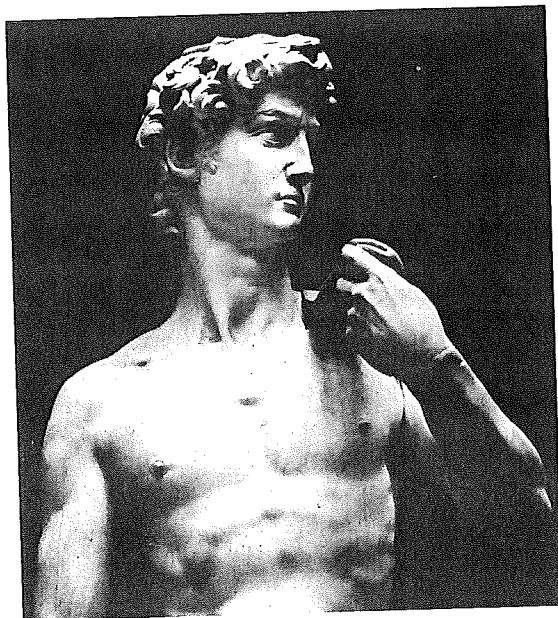
Flemish artists experimented with paints that had an oil base. The new oil paints dried more slowly and were easier to blend. Therefore, artists could create subtle new shades.

Great Italian Artists

During the opening decades of the 1500s, three artists dominated the world of Italian art: Leonardo da Vinci, Michelangelo, and Raphael Santi. Together with many other Renaissance artists, these artists have influenced painting and sculpture until the present.

Leonardo da Vinci. Leonardo da Vinci achieved the Renaissance goal of doing many things and excelling in all. He was

Leonardo da Vinci's Mona Lisa is one of the most famous works of art in the world. Most people remember the haunting smile of the woman in this painting. The portrait is of Lisa della Gioconda, wife of a Florentine merchant.



Michelangelo's David symbolizes the spirit of the Renaissance, proud, fierce, and confident. The statue still stands in the heart of Florence. To the people of Florence, the Biblical hero David represented independence and liberty.

curious about everything. He continually observed the world around him and recorded his findings in dozens of notebooks. Because he was fascinated by flight, he observed birds on the wing. In his notebooks, he showed how he thought humans might use wings to fly. In order to understand the anatomy of the human body, he dissected corpses. He then used his knowledge to paint more realistic figures.

Sadly, much of Leonardo's work has been lost. Only 15 of his paintings survive, including such masterpieces as the *Last Supper* and the *Mona Lisa*.

Michelangelo. Like Leonardo, Michelangelo had many talents. He considered himself first and foremost a sculptor, but he was also an accomplished musician, poet, painter, and architect. Like other Renaissance sculptors, Michelangelo carefully studied the human figure. Yet Michelangelo's figures do not exhibit the relaxed poses of other sculptures, such as Donatello's David. Instead, Michelangelo's statues of David and Moses convey a sense of tension.

In 1508, Pope Julius II asked Michelangelo to paint the ceiling of the Sistine Chapel

in the Vatican, the pope's palace in Rome. Michelangelo devoted four years to the task. For hours each day, he lay on his back atop a high scaffold and painted scenes from the Bible, such as God creating the world, Noah and the flood, and Christ's crucifixion.

Raphael. Raphael Santi was a skillful painter whose work was influenced by both Leonardo and Michelangelo. Born in Umbria, Raphael favored the bright colors traditionally used by painters from that region of Italy. He often painted the Madonna, or mother of Jesus, and the infant Jesus. Unfortunately, Raphael's promising career was cut short by his death at age 37.

Artists of Northern Europe

In the 1400s and 1500s, northern European painters also created splendid masterpieces. Because ancient Roman ruins lay beyond the Alps, northern artists were less influenced by classical styles than their contemporaries in Italy. However, rules of perspective and the new oil-based paints did affect their work and marked a break with medieval painting.

Flanders was the artistic center of northern Europe. Flemish artists such as Jan van Eyck (van IK) were interested in painting the world realistically. To do this, van Eyck gave careful attention to detail. When he painted a satin robe, every fold was drawn exactly. Similarly, every jewel in a royal crown sparkled. Van Eyck's paintings often had a religious message. Each object had a symbolic meaning that reinforced the message of the painting.

Another Flemish painter, Pieter Bruegel (BROI guhl), found inspiration in everyday scenes of peasants working and in country landscapes. Although Bruegel showed the lives of common people in his paintings, he sometimes used symbolic figures, as van Eyck had, to express deeper meanings. Bruegel influenced later Flemish and Dutch painters, who painted scenes of daily life rather than religious or classical themes.

Many German artists painted realistic portraits. For example, Hans Holbein the Younger painted portraits of nobles and rulers, as well as of philosophers and com-



Northern Renaissance artists often painted realistic scenes of everyday life. This painting by Jan van Eyck shows the artist's friend Giovanni Arnolfini with his wife Jeanne Cenami. Many details of home life can be seen in the painting. Certain details have a symbolic meaning. The little dog is a symbol of faithfulness. The single lighted candle in the chandelier represents the presence of Christ. The writing above the mirror reads: "Jan van Eyck was here."

moners. Another German artist, Albrecht Dürer (DYOO ruhr), traveled to Italy to study the techniques of the Italian masters. Dürer helped spread their ideas across northern Europe.

Renaissance Writers

Like painting and sculpture, literature expressed the attitudes of the Renaissance. In towns and cities, the middle class formed a

demanding new audience, especially for popular literature such as dramatic tales and comedies.

Popular literature was often written in the vernacular although many Renaissance writers continued to use Latin. (See page 65.) The Italian writer Petrarch, for example, felt comfortable writing in either Latin or Italian. His works included poetry and polished essays written in the form of letters. Petrarch perfected the sonnet, a 14-line poem that expresses a complete thought.

Another Italian writer, Giovanni Boccaccio (boh KAH chee OH), also contributed to Renaissance literature. Boccaccio's best known work is the *Decameron*, 100 stories told by seven men and three women who had fled from a plague in Florence. The *Decameron* was the first prose work written in Italian. Its clear narrative style served as a model for later writers.

The French writer François Rabelais (RAB uh LAY) fit the ideal of a Renaissance person. He began his career as a monk. Later, he studied the classics and trained in medicine. Rabelais exhibited immense curiosity, which he summed up in these words: "Abandon yourself to Nature's truths, and let nothing in this world be unknown to you."

Rabelais expressed his view of the world through two famous characters he created: the giant Gargantua (gahr GAN choo wuh) and his son Pantagruel (pan TAG roo WEHL). Gargantua wanted his son to study everything in the arts and sciences. He also advised Pantagruel to learn Arabic, Latin, Greek, and Hebrew. Rabelais' writing contained witty discussions of philosophy and politics.

Miguel de Cervantes (suh VAN teez) was a leading Renaissance writer in Spain. An adventurer, Cervantes served in the Spanish army. He was captured by pirates and held as a slave in North Africa for five years. Later, he turned to writing.

In his novel *Don Quixote* (DAHN kee HOHT ee), Cervantes gently mocked the medieval ideals of chivalry. The hero, a knight named Don Quixote, believed so strongly in chivalry that he kept imagining

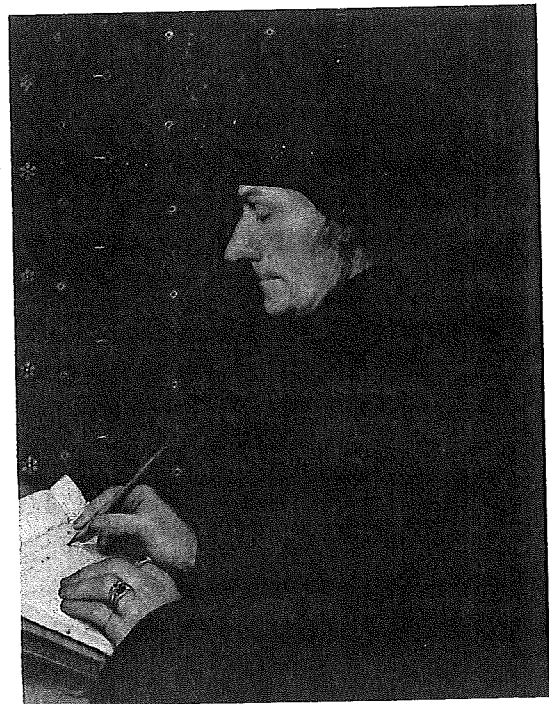
himself in the middle of dangerous adventures. Sancho Panza, Don Quixote's servant, tried without success to convince the knight that the "castles" he saw were only lowly inns and the "jousting knights" were simply windmills.

Poet and playwright William Shakespeare is one of the finest writers in the English language. He wrote tragedies, comedies, and historical dramas, which were performed at the Globe Theater in London. In London, as in other European cities, both well-to-do and poorer people attended the theater. At the theater, they found entertainment, but they also learned about the ideas of their times.

A Call for Reform

Renaissance writers emphasized religious as well as worldly themes. In the early 1500s, some Christian scholars who had made a

"If anyone has not seen Erasmus, this portrait, drawn skillfully from life, gives his image." So wrote Hans Holbein the Younger, the German artist who painted this portrait of Erasmus. An influential Renaissance figure, Erasmus was called "the Scholar of Europe."



study of the Bible and early Christian writings urged reform of the Church. They wanted the Church to return to its early traditions based on the teachings of Jesus. These reformers were called Christian humanists.

In northern Europe, the Dutch scholar and priest Desiderius Erasmus (ee RAZ muhs) led the Christian humanists. Erasmus knew Greek so he could study early copies of the New Testament, which were written in Greek. In *Praise of Folly* and other works, Erasmus used witty dialogues to point out the ignorance of some clergy. He also criticized the Church for emphasizing pomp and ritual rather than the teachings of Jesus.

Despite his criticism of Church practices, Erasmus accepted its teachings. He remained in the Church even when other reformers rejected its authority and established their own churches.

A friend of Erasmus who shared his concerns was the English scholar and statesman Sir Thomas More. More thought that literature should serve Christian goals. In his

book *Utopia*, More described an ideal society in which people lived at peace with one another.* He created an imaginary kingdom to show how such a society should be organized. Later writers used More's method to express their own ideas about society.

* Today, the word utopia is used to mean a perfect place or situation.

SECTION REVIEW

1. Identify: Donatello, Brunelleschi, Leonardo da Vinci, Michelangelo, Raphael, Jan van Eyck, Pieter Bruegel, Albrecht Dürer, Botticelli, Rabelais, Cervantes, Shakespeare, Erasmus, Sir Thomas More.
 2. How was Donatello's David different from medieval sculpture?
 3. Describe two new techniques that affected Renaissance art.
 4. How did artists of northern Europe differ from Italian artists?
 5. (a) Why did Erasmus criticize the Church? (b) What did he think the Church should emphasize?
-

3 Changing Patterns of Life

During the Renaissance, only a relatively few people were directly affected by the outpouring of creative genius in literature and the arts. The wealthy filled their palaces with artistic masterpieces. They also had the leisure time to read widely and expand their knowledge of the world. However, in later years, advances in technology gradually helped spread the new learning to a wider audience. As a result, Renaissance learning slowly filtered into the lives of ordinary people.

The Introduction of Printing

The invention of printing in the 1400s dramatically affected the production of books. Before this time, few books were reproduced because each one had to be copied by hand. A good copier could complete only about

two books a year. Furthermore, books were costly because they were written on parchment made from the skin of a sheep or goat.

Both problems were gradually overcome. In the 1300s, Europeans learned from the Arabs how to make paper from rag and wood pulp. The Arabs had learned about papermaking from the Chinese.

The technique of printing also grew out of earlier developments. In the 1300s, engravers experimented with printing books from wood blocks. They carved a page on the block, which was then inked and pressed on paper. By the 1440s, German engravers had developed movable type. Movable type consisted of tiny pieces of metal engraved with a letter. The pieces of metal could be combined to form words and then sentences. Also, the pieces of metal could be used again and again.

The final step in the development of printing was probably taken by Johann Gutenberg in Mainz, Germany. Gutenberg invented a metal alloy that could be used to make movable type. He developed a printing press that used this alloy. In 1455, he used his invention to print a complete edition of the Bible. With the Gutenberg Bible, as it was called, the era of printed books began.

Printing spread rapidly. By 1500, there were over 250 presses in Europe turning out books. As printing methods improved, the cost of producing books fell. Because prices were reasonable, people who could never have afforded hand-copied books now bought printed books.

The use of paper and the development of printing had a revolutionary impact on the world of learning. Books could be produced more quickly and less expensively than before. Ideas spread rapidly through the printed word. Many of the newly printed books were religious works such as the Bible

and biographies of saints. Others dealt with subjects ranging from mining and medicine to philosophy and politics. The availability of books on the sciences and technology would greatly affect the Scientific Revolution, which you will read about in Chapter 9.

Everyday Life

For people in Renaissance Europe, life was much as it had been for their parents and grandparents. However, social and economic changes were slowly taking place.

In medieval Europe, most people lived in an *extended family*. On the manor, for example, the extended family was an important economic unit because many people were needed to work the land. During the Renaissance, the nuclear family gradually began to emerge, especially in the towns and cities. In a *nuclear family*, only parents and their children live in a household.

The impact of printing was enormous because books, especially the Bible, became more readily available. This picture shows different phases of early printing. In the background, typesetters select pieces of movable type from the trays. In the foreground, a printer prepares to take a printed page off the press. The first printing presses were fairly simple machines adapted from wine presses.





The Flemish painter Pieter Bruegel was nicknamed "peasant Bruegel" because of paintings such as this Peasant Wedding. This painting offers a realistic view of everyday life. The young peasant bride is seated against the dark background. How is this wedding scene different from the one on page 136?

Another change affected the way businesses were run. Most businesses in the Middle Ages were small and were managed by a single family. During the Renaissance, some people formed business partnerships with people outside the family. Two or more families might pool their resources in order to expand business activities.

Some changes in agriculture and industry were the result of the continuing effects of the Black Death. (See page 87.) The Black Death had greatly reduced the population of Europe. Thus, the demand for wheat and other grains fell. Farmers began producing new types of food, which they hoped would be more profitable. The new foods included meat, fruit, and dairy prod-

ucts such as cheese and butter. As these products gradually became more plentiful, people's diets changed.

As a result of the Black Death, the demand for manufactured goods such as wool cloth also fell. In Florence, for example, half the population had died of the plague, and wool production dropped drastically. The demand for wool cloth increased when the population throughout Europe began to grow again. Wool workers then found their skills in much demand, and they asked for higher wages. When employers tried to keep wages low, the workers revolted. Although worker revolts were brutally suppressed, the wages of city workers did rise during the Renaissance.

Isabella d'Este: A Renaissance Person

At the height of the Renaissance, Isabella d'Este ruled over Mantua, one of the most brilliant courts in Italy. She so impressed her contemporaries with her knowledge, lively wit, and political skill that they called her "la prima donna del mondo"—"first lady of the world."

Isabella d'Este began life with many advantages. Her family, the Este, ruled Ferrara, a wealthy city-state in the Po River valley. At the time of Isabella's birth in 1474, the Este court sparkled as a center of Renaissance culture.

During the Renaissance, noble families like the Este often gave their daughters as well as their sons a thorough education. As a child, Isabella studied the humanities, including Latin and Greek. A fast learner, she astonished visitors when she quoted the verses of Virgil



from memory or translated the letters of Cicero.

Isabella also learned to sing, play the lute, dance, and embroider. With her lively intelligence and fine education, she was able to talk easily with the scholars and artists who visited her father's court. By the time she was married, at age 16, Isabella fit the Renaissance ideal of a cultivated individual with many skills and talents.

Isabella married Francesco Gonzaga, heir to the ruler of Mantua, a small but wealthy Italian city-state. In addition to being a wife and mother of nine children, Isabella devoted herself to Mantua.

The Italian city-states were nests of intrigue. Rivalries among the cities and the ambitions of French and Spanish kings caused frequent fighting. A skillful diplomat, Isabella helped her husband preserve the safety of Mantua. When the Venetians captured Francesco, Isabella ruled in his absence. Despite threats of invasion, she kept the people of Mantua calm and eventually secured her husband's release.

In Mantua, Isabella set the artistic fashions and standards of her day. Writers, artists, and poets gathered around her. She was a generous but demanding patron of the arts. She collected the finest paintings as well as marble and bronze statues, crystal, jewels, and clocks. Poets wrote songs in her honor, and books printed in Venice were sent to Mantua for her approval.

During her lifetime, Isabella wrote more than 2,000 letters, which show the wide range of her interests. In them, she commented on everything from art and politics to war and family matters. She knew the leading figures of the Renaissance, from Michelangelo and Leonardo da Vinci, who sketched this portrait of her, to the pope and the most powerful kings of Europe.

Women in the Renaissance

Women's occupations changed little during the Renaissance. Their main responsibilities remained in the home, where they raised the children and took care of the family. At sowing and harvesting time, farm women and children worked in the fields alongside the men.

However, women also worked outside the home. Some women were employed as servants in households of wealthy farmers, merchants, or nobles. Many women also earned money as spinners and weavers, although most workers in the cloth industry were men. Women in the merchant class helped manage family businesses. In addi-

tion, many farm and city women ran their own small businesses, selling handwork or garden produce at local markets.

A few women played central roles in governing city-states or nations. Queen Isabella of Spain, for example, was a forceful and effective ruler. (See page 85.) At different times during the Renaissance, queens ruled Naples, Scotland, and England. In France, Catherine de Medici, the widow of King Henry II, acted as regent* for her young sons until they were old enough to rule.

Some Renaissance scholars argued that women as well as men would benefit from

* A regent governs in place of a monarch who is too young or is otherwise unable to rule.

studying the classics. As the number of schools increased, more women learned to read and write. For example, Isabella d'Este received an excellent education that enabled her to translate Greek and Latin writings and take part in the learned discussions of her day.

SECTION REVIEW

1. Identify: Johann Gutenberg.
 2. How did the introduction of printing affect the spread of ideas?
 3. Describe one way in which the Black Death affected farming during the Renaissance.
 4. Give three examples of work some women did outside the home.
-

4 Beginnings of the Protestant Reformation

During the Middle Ages, various reform movements had restored the vigor of the Roman Catholic Church. However, during the Renaissance, many pious Christians again clamored for reform. Unlike earlier reform efforts, which had strengthened the Church, these efforts shattered forever the medieval ideal of the unity of Christendom.

Need for Reform

In the 1300s and 1400s, many Christians lost confidence in the Church's ability to provide religious leadership. The Babylonian Captivity and the Great Schism had seriously hurt the power and prestige of the Church. (See page 89.) To many, the Church seemed overly concerned with worldly affairs. The pope and clergy tried to preserve Church privileges as powerful monarchs chipped away at its power. Rulers of France, Spain, and Germany often interfered in Italian affairs. As a result, the pope became involved in long, costly wars to protect the Papal States from outside control.

The worldliness of the Church was evident in the pomp and splendor surrounding

the papal court. For example, in 1506, Pope Julius II decided to rebuild St. Peter's Cathedral in Rome. He hired architects and artists such as Michelangelo to design and decorate the new church.

To finance such projects and pay for their wars, Renaissance popes devised new ways to raise money. They increased the fees that Christians paid for baptism, marriage, and funerals. They also permitted the sale of indulgences. An *indulgence* was the reduction of the punishment a sinner would suffer in purgatory after death.

Indulgences were first granted during the Crusades, when the pope agreed to cancel penalties for any sins that a crusader committed. Eventually, popes granted indulgences not only for a specific service, such as going on a crusade, but also for money contributions to the Church. By the 1500s, people could buy indulgences to cancel the punishments dead relatives might be suffering in purgatory.

Many faithful Christians protested such practices. They also objected to the worldliness of the Church. As you read in Chapter 5, reformers such as Wycliffe and Huss had gained many followers for their teachings,

which emphasized the Bible and the simple lives led by early Christians.

In the 1490s, an outspoken monk, Girolamo Savonarola (SAV oh nuh ROH luh), preached reform in Florence. He attacked the Church and condemned immorality. He inspired his audiences to reject their worldly possessions. Eventually, Savonarola was executed for heresy. Elsewhere, Christian scholars such as Erasmus also urged reform. Their suggestions for reform were soon taken up by others who introduced revolutionary changes.

Luther's Challenge

In 1517, the written protests of a German monk, Martin Luther, sparked a reform movement that split the Roman Catholic Church. The son of a wealthy peasant, Martin Luther studied law. In 1505, during a summer storm, Luther was knocked to the ground by a bolt of lightning. "St. Anne, help me!" he cried out in terror. "I will become a monk."

True to his word, Luther entered a monastery and later taught Bible studies at the University of Wittenberg in Saxony. He tried to lead a holy life. However, he became convinced that good works such as fasting and prayer did not ensure salvation because a person could not buy God's favor. He believed that God would grant salvation regardless of whether or not a person did good works.

The 95 theses. Luther's beliefs led him to denounce the practice of granting indulgences. In 1517, the monk Johann Tetzel was actively selling indulgences near Luther's home at the University of Wittenberg. Tetzel was quoted as saying, "As soon as the coin in the coffer rings, the soul from purgatory springs." Tetzel was collecting huge sums of money to be sent to Rome.

Luther was outraged at Tetzel's activities. He posted 95 theses, or questions for debate, on the door of the Wittenberg castle church. In the 95 theses, he condemned the selling of indulgences. He argued that indulgences could neither release a soul from purgatory nor cancel a person's sins.

Within weeks after Luther's attack, his message had been printed and spread across Europe. Forced to defend his statements, Luther expanded his criticism of the Church. Soon he was denying Church authority in other matters. He claimed that the authority of the Bible and a person's own conscience outweighed the pope's authority.

Pope Leo X became alarmed at the activities of the "wild boar," as he called Luther. In 1520, he excommunicated Luther. The next year, the Holy Roman emperor Charles V questioned Luther before the Imperial Diet, or assembly, then meeting at Worms. Luther refused to withdraw his criticisms of the Church. Instead, he declared: "I cannot . . . go against my conscience. Here I stand. I cannot do otherwise. God help me." Luther's stand established him as the leader of reform-minded churches in the Holy Roman Empire.

Luther's teachings. Three ideas were at the core of Luther's reforms. First, he taught that individuals could not achieve salvation by their own efforts, such as by performing good works. A person's only hope of salvation was faith in God's mercy. The watchwords of Luther's teaching were "faith alone."

Second, Luther established the Bible as the only guide for Christians. He rejected many Church ceremonies as well as the authority of the pope because he said the Bible made no mention of them.

Finally, Luther emphasized the role of the individual. "The pope is no judge of matters pertaining to God's word and faith," he said. "But the Christian man must examine and judge for himself." He claimed that the individual did not need a priest to interpret the Bible. Like Wycliffe and Huss, he urged Christians to read the Bible themselves. Luther translated the Bible into the German vernacular and conducted services in German, instead of Latin, so that people could understand what was being said.

Luther also made other changes. For example, he simplified religious services and rituals. He allowed priests to marry because the Bible had not forbidden it. Such changes were adopted by the Lutheran churches organized by Luther's followers.



In 1521, Martin Luther was called before Charles V, the Holy Roman emperor, at the Diet of Worms. Luther, standing in the center of this picture, expected to be allowed to explain his views. Instead, the emperor asked him to renounce his heresy. When Luther refused, Charles V declared him an outlaw. Luther found refuge in Saxony, where he translated the New Testament into German in just 11 weeks.

Impact of Luther's Reforms

Luther's ideas won widespread support in Germany. Among the clergy, many sympathized with his criticism of Church abuses. In the towns, some people applauded Luther's reforms because they resented paying Church taxes, which were sent to Rome. Some townspeople echoed Luther's warning that any messenger from Rome seeking money "should receive a strict command either to keep his distance, or else to jump into the Rhine or the nearest river, and take ... a cold bath." Many town governments eagerly took over Church property, and they soon established independent churches.

Some German princes supported Luther and his followers. They wanted to assert their independence of the Holy Roman em-

peror. Like townspeople, princes seized Church lands and stopped the flow of Church taxes to Rome. When the emperor tried to force the German princes to remain loyal to the pope, they protested. They became known as Protestants. Later, the movement to reform the Church was called the Protestant Reformation.

Luther's reforms also appealed to the peasants, who bore a heavy burden of Church taxes. Peasants eagerly accepted the idea that the individual Christian was free to interpret the Bible. Moreover, they took the idea of freedom a step further and began to voice other complaints against the Church and noble landlords. In 1524, the Peasants' Revolt broke out in Germany. Peasants demanded the right to read the Bible and choose their own ministers. They also

wanted to end serfdom and feudal rent payments, which were still required.

At first, Luther supported the peasants' demands. Later, he drew back in horror when he heard reports of peasants burning, looting, and killing. He bitterly criticized their actions and sided with the nobles, who ruthlessly stamped out the revolt. From this time on, Luther and his followers rejected political revolution. Many peasants felt betrayed by Luther and eventually returned to the Catholic Church. By Luther's death in 1546, about half the princes within the Holy Roman Empire had adopted the new Protestant faith.

In response to the success of the Protestants, the Holy Roman emperor Charles V launched a military campaign in 1547 to force the Lutheran princes back into the Catholic Church. When neither side could win the war, Charles accepted a compromise. In 1555, at the Diet of Augsburg, he agreed that each prince could choose whether his territory would be Catholic or Lutheran. By allowing individual rulers to

determine the religion of a territory, the Peace of Augsburg officially recognized the split within Christendom.

By 1555, most princes in northern Germany were Lutheran, while most princes in southern Germany were Catholic. Lutheran ideas had also spread to Scandinavia. However, the Peace of Augsburg did not end the dispute between Catholics and Protestants. Other reformers had also broken away from the Catholic Church, and they were winning followers across Europe.

SECTION REVIEW

1. Identify: Martin Luther, Johann Tetzel, Peace of Augsburg, Protestant Reformation.
 2. Define: indulgence.
 3. How was the Church affected by the actions of European monarchs?
 4. (a) What Church practice did Luther attack in his 95 theses? (b) Describe two major teachings of Luther.
 5. Give one reason why German princes supported Luther.
-

5 Further Challenges to the Catholic Church

From Germany, Protestant ideas spread to other parts of Europe as reformers challenged the authority of the pope. In England, King Henry VIII challenged the pope not on questions of religious faith but on more worldly matters. As new Protestant movements sprang to life, the Catholic Church took decisive steps to stop them and to revive its spiritual leadership of the Christian world.

The Spread of Protestant Ideas

Switzerland emerged as a center of the Protestant Reformation. Ulrich Zwingli, a priest and admirer of Erasmus, taught in the Swiss city of Zurich during the same years that Luther was launching the Reformation in Germany. Like Luther, Zwingli had no use for elaborate church rituals. In his church, he

abolished the Catholic Mass, confessions, and indulgences. He also allowed priests to marry.

Zwingli believed that a good pastor, or minister, and a strong sense of discipline among church members would help Christians lead a spiritual life. He held services in undecorated buildings and read sermons based on the Bible. By 1529, Zwingli's ideas had spread to many parts of Switzerland.

John Calvin. In the Swiss cities of Basel and Geneva, John Calvin led one of the best-organized Protestant movements. Born in France, Calvin studied law at the University of Paris before he decided to devote his life to religion. As part of his studies, Calvin read the works of Erasmus and Luther. In 1536, he published the *Institutes of the Christian Religion*, in which he outlined his beliefs in a clear, orderly way. The *Institutes* had a profound influence on Protestant thought.

Like Luther, Calvin rejected the idea that good works would ensure salvation. However, Lutheran and Calvinist teachings differed in emphasis. Luther taught that people could work toward their own salvation through faith in God. Calvin stressed the all-powerfulness of God. God alone, Calvin said, decided whether an individual received eternal life.

Calvin believed in *predestination*, the idea that God had chosen who would be saved and who would be condemned. Calvin's critics warned that predestination would lead people to act irresponsibly. Why should individuals lead a good life, they asked, if God had already determined their fate? But Calvin answered that people should lead good lives in order to show that God had chosen them for salvation.

Calvin established a church with strong, disciplined leadership. Calvinists practiced the strict morality taught in the Old Testament. With the *Institutes* as a guide, the new faith spread rapidly.

Calvinists won many converts in commercial centers such as the Netherlands. There, as elsewhere, middle class townspeople were attracted to Calvinism because it reflected their belief that people should live simply and work hard. Moreover, Calvinism answered many people's criticisms of the Catholic Church. French Calvinists, called Huguenots (HYOO guh NAHTS), were powerful in southern France. During the 1550s, John Knox took the new faith to Scotland. Followers also established churches in England, where they eventually became known as Puritans.

Other Protestant groups. A number of Protestant sects sprang up all across Europe. Some clashed violently with each other and with Catholics. Each group saw itself as God's agent and viewed all others as the devil's workers. Many years would pass before Europeans accepted the idea that two or more religions could coexist.

Protestant sects developed their own beliefs based on reading and interpreting the Bible. For example, Anabaptists—later called Baptists—argued that infants could not be baptized as members of a church because they were too young to understand the

Christian faith. They restricted baptism and church membership to adults. Anabaptists in Germany were vigorously persecuted by other Protestants and Catholics alike. Yet their ideas continued to influence Protestant thinking in many countries.

Henry VIII's Quarrel with Rome

Throughout his life, Henry VIII of England considered himself a faithful Catholic. In 1521, Henry published a stinging attack on the teachings of Martin Luther. The attack delighted the pope, who awarded Henry the title "Defender of the Faith." However, a few years later, the king was at odds with the Catholic Church over the issue of marriage.

After 18 years of marriage to Catherine of Aragon, Henry had no son to inherit the English throne. Catherine had given birth to many children, including several boys, but only one child, Mary Tudor, survived infancy. When Henry asked Pope Clement VII to grant him an annulment* so he could remarry, the pope refused. A strong-willed man, Henry would not accept defeat. Instead, he built up English sentiment against the pope.

Between 1529 and 1536, Henry took the English church from under the pope's control and placed it under the king's. In 1533, the Archbishop of Canterbury, Thomas Cranmer, annulled Henry's marriage to Catherine of Aragon. Henry then married Anne Boleyn. Parliament recognized the king as the supreme head of the Church of England by the Act of Supremacy of 1534.

English Protestants applauded the steps taken by the king and Parliament to break away from Rome. However, other English reformers, such as Sir Thomas More, wanted change to come from within the Catholic Church. Henry feared his opponents would disrupt the peace so he ordered the execution of More and others who would not accept the Act of Supremacy.

Before long, Henry took further steps against the Catholic Church. When he heard reports that many monasteries were corrupt, the king promptly closed them. About 10,000

*An annulment is an official statement declaring a marriage invalid.

English monks and nuns were forced to seek other homes. Because he needed money, the king then seized monastery lands, which he sold to nobles, wealthy farmers, and merchants. In the years ahead, those who bought monastery lands would resist any effort to restore land or power to the Catholic Church.

Despite the break with Rome, Henry did not want to change Catholic beliefs. In fact, Henry proclaimed that the Anglican Church, as the Church of England was called, would preserve traditional Catholic practices. However, he did allow priests to use an English translation of the Bible, and he permitted them to marry.

A Protestant Nation

Henry VIII died in 1547 after a turbulent life that included six marriages. After his death, the official religion of England swung back and forth between Protestant and Catholic. Henry's son, Edward VI, inherited the throne at age ten. During Edward's reign, Protestant bishops issued the *Book of Common Prayer*, which outlined the official rituals and prayers for the Anglican services. The *Book of Common Prayer* combined both Protestant and Catholic ideas.

When Edward died in 1553, Henry VIII's daughter, Mary Tudor, inherited the throne. Raised as a Catholic, Mary was determined to make England truly Catholic again. She persecuted Anglican bishops who would not accept the authority of the pope. Mary angered many subjects when she married Philip II, the Catholic king of Spain. When Mary died in 1558, her Protestant half-sister, Elizabeth I, became queen.

Queen Elizabeth adopted a skillful policy of religious compromise. She moved cautiously at first but gradually enforced reforms that she felt moderate Catholics and Protestants could accept. However, Elizabeth persecuted both Catholics and Protestants who opposed her policies. Elizabeth firmly established England as a Protestant nation. Yet she took England along a middle road and preserved many traditional Catholic beliefs.



Elizabeth I, Protestant Queen of England, did not personally feel strongly about religion. But she wanted to restore unity to a nation divided over religious questions. Therefore, Elizabeth I reaffirmed the role of the monarch as head of the Anglican church and completed the seizure of church lands that her father had begun.

The Catholic Reformation

During the Protestant Reformation, many loyal Catholics worked to revive the spiritual leadership of the Catholic Church. In addition, they fought against Protestants, who they regarded as heretics. The movement to reform the Catholic Church and fight Protestants became known as the Catholic Reformation. Some historians have also called it the "Counter Reformation."

Paul III, who was pope from 1534 to 1549, led the reform of the Catholic Church. Paul appointed able scholars and reformers to high church offices. He also summoned many officials to a church council at Trent to discuss reforms.

The Council of Trent was in session from 1545 to 1563. In response to Protestant attacks, the council reaffirmed traditional Catholic doctrines. The council also re-

formed church finances and administration and called for better training of priests. As a result of the Council of Trent, the Catholic Church ended many abuses that Luther and other Protestant reformers had criticized. Catholic rulers in Spain, France, and Italy strongly supported the reforms.

New religious orders helped strengthen the Catholic Church. In Spain, Ignatius of Loyola formed the Society of Jesus, a group of dedicated missionaries. As a young knight, Loyola had been wounded in battle. While recovering from the injury, he spent hours reading about the saints and thinking about religious questions. Loyola then wrote *Spiritual Exercises*, a manual that taught strict religious discipline.

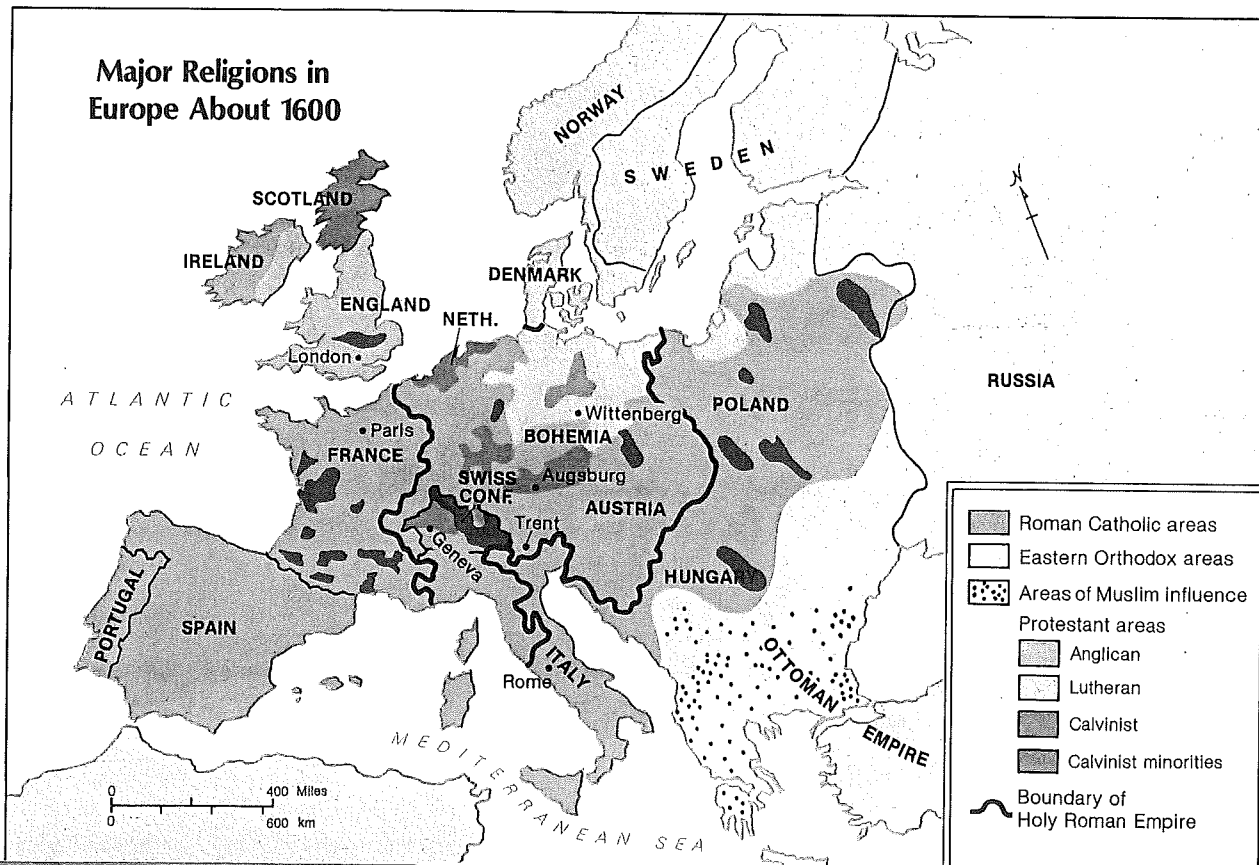
In 1540, Pope Paul III officially recognized the Society of Jesus. The Jesuits, as Loyola's followers were called, swore absolute obedience to the pope. They traveled to the new lands that Europeans were exploring and won many converts. In addition,

they brought many Protestants in Germany and Eastern Europe back into the Catholic Church.

The Catholic Church also took other steps to stop the spread of Protestant ideas. For example, it revived the Inquisition. As you read earlier, the Inquisition was the church court that had tried to root out heresies during the Middle Ages. The Inquisition was most active in Spain, Portugal, and Italy. In addition, the Catholic Church published the *Index*, a list of forbidden books. By limiting what books Catholics could read, the church hoped to prevent the spread of the Protestant ideas.

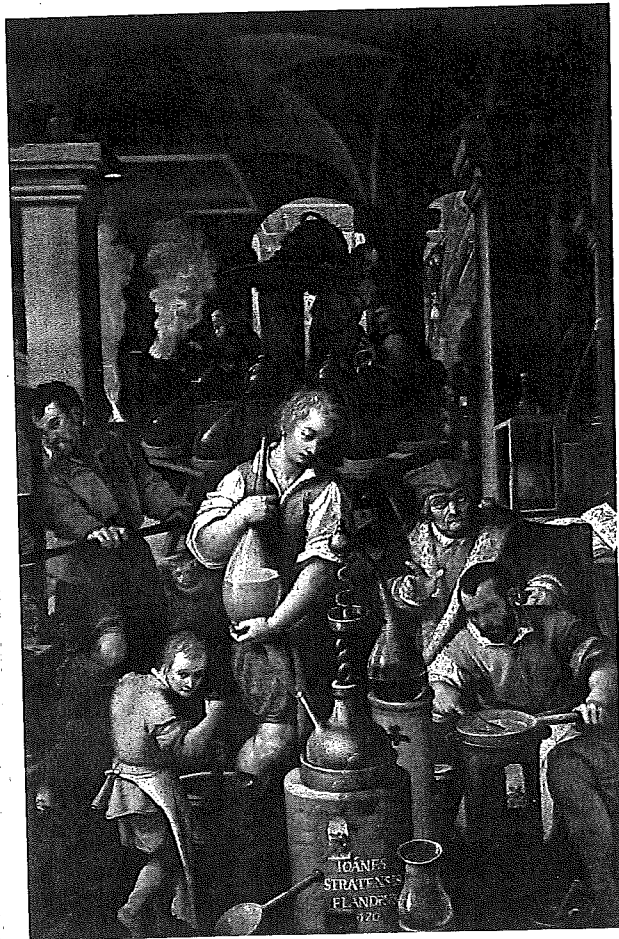
After the Catholic Reformation, Protestants made few new gains. By 1600, the lines between Catholic and Protestant areas in Europe were sharply drawn. They have remained largely unchanged to the present. Lutherans, Calvinists, and other Protestant sects flourished in England, Scotland, Scandinavia, and northern Germany. Under

■ The Protestant Reformation shattered the unity of Christendom, as you can see on this map. Anglicans, Lutherans, and Calvinists, as well as other Protestant groups, such as the Anabaptists, established churches. Which parts of Europe were most affected by the Protestant Reformation?



9 The Scientific Revolution and the Enlightenment

(1500–1800)



The Alchemist, by Giovanni Stradano.

Chapter Outline

- 1 New Directions in Science
- 2 Enlightenment Thinkers
- 3 Impact of the Enlightenment

One day in 1671, Anton van Leeuwenhoek (LAY vuhn HOOK), a Dutch cloth merchant, took a glass lens used to examine the weave of different fabrics and mounted it between two metal plates. He then constructed a specimen holder and attached it to his simple magnifying glass. With this primitive microscope, Leeuwenhoek began to study such everyday objects as bits of pepper and plant seeds as well as his own skin.

Eventually, Leeuwenhoek put a drop of water on the specimen holder and peered through his microscope. He was amazed to find what he called little “wretched beasties” swimming around in the droplet of water. He

described these creatures as “moving about very nimbly” because they had “incredibly thin feet!” What Leeuwenhoek saw were single-cell living organisms such as bacteria.

Leeuwenhoek’s startling discovery created a stir among scholars because it opened up a whole new world of study. As Leeuwenhoek and other scientists pursued their investigations using the microscope, they discovered hundreds of previously unknown organisms. As they learned more about the life cycles of these tiny organisms, they had to discard long-held ideas about biology.

During the 1500s and 1600s, inventions such as the microscope and numerous other discoveries transformed the natural sciences and medicine. New technology and improved methods of research led to an explosion in knowledge that became known as the Scientific Revolution.

Discoveries about the physical world affected philosophers. They applied scientific principles to the study of government and society. During the first

half of the 1700s, philosophers emphasized the use of reason. They thought that people should use reason to free themselves from ignorance and superstition and thereby become enlightened. They were convinced that enlightened people could perfect themselves and society. Thus, the eighteenth century is known as the Enlightenment.

Together, the Scientific Revolution and the Enlightenment would change the way people saw the world and help shape the attitudes that made the scientific advances of the modern world possible.

1 New Directions in Science

During the Renaissance, a spirit of curiosity encouraged a few people to study the natural world. For example, the painter and sculptor Leonardo da Vinci kept detailed notebooks in which he described his scientific observations. He drew plans for fantastic inventions including a flying machine and a device that looked like a bicycle. By the late Renaissance, scholars had greatly expanded scientific knowledge and developed a new approach to scientific studies.

The Scientific Method

The ancient Greek philosopher Aristotle created a system of thought based on observation and a process of reasoning called logic. During the Middle Ages, the teachings of Aristotle dominated scientific thinking.

Between 1200 and 1700, scholars began questioning the views of ancient philosophers. Some scholars made observations and conducted experiments that disproved accepted theories. At the same time, the increased use of Arabic numerals led to advances in mathematics that revealed errors in Aristotle's logic.

Slowly, scholars developed a new approach to the study of the natural world. Today, this approach is called the scientific method. The *scientific method* is a threefold approach to scientific study. First, careful experiments and observations are made. Second, reason is used to interpret the results of the experiments and observations. Third,

mathematics rather than logic, or reasoning from principles, is used to prove scientific theories.

Copernicus

Nicolaus Copernicus (koh PUR nih kuhs), a Polish mathematician and astronomer, played a central role in developing the scientific method. In 1543, he published *On the Revolutions of the Heavenly Bodies*. His work challenged Ptolemy's view of the universe. Ptolemy taught that the earth was the center of the universe and the sun and other planets revolved around it in perfect circles.

Copernicus used mathematical calculations to show that Ptolemy was wrong on two crucial points. First, Copernicus said that the earth was not stationary but that it turned on its axis once a day. Second, he declared that the earth was not the center of the universe. He argued that the earth and the planets revolved around the sun in perfect circles. Although Copernicus' theories were partly correct, he could not provide enough convincing evidence to prove that Ptolemy was wrong. As a result, many educated people rejected his views.

Many scholars argued that Ptolemy and the other ancient philosophers could not have been wrong. In Western Europe, all scientific knowledge and many religious teachings were based on the logical arguments developed by the ancient philosophers. The

scholars thought that if their reasoning about the planets was wrong, then the whole of human knowledge would become uncertain.

Although Copernicus' ideas were not readily accepted, they had far-reaching consequences because they affected the method of testing ideas. After Copernicus, scientists increasingly backed up observation of nature with mathematical calculations.

Further Discoveries

In the late 1500s, Danish astronomer Tycho Brahe built an observatory to study the planets and stars. He carefully recorded what he saw, and his assistant, Johannes Kepler, used this information to prove Copernicus' theories.

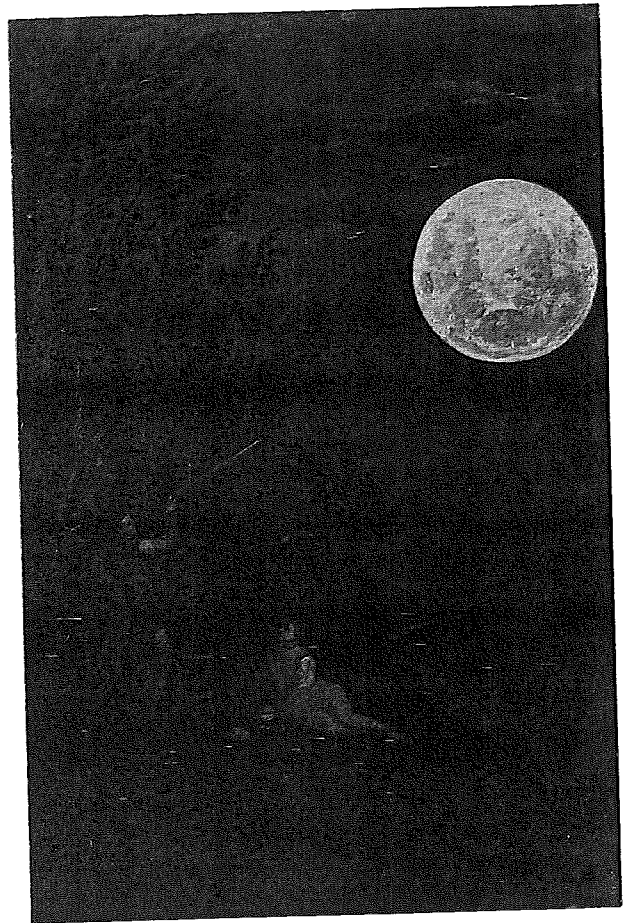
Like Copernicus, Kepler thought that the earth and other planets traveled around the sun. Kepler performed thousands of hours of calculations based on Brahe's observations. His calculations supported the idea that the planets revolve around the sun but not that they revolve in perfect circles as Copernicus had thought. In 1609, Kepler announced that the planets move in another kind of orbit, called an ellipse.

In Italy, the astronomer Galileo Galilei used a new magnifying instrument, the telescope, to observe the planets and stars. His observations led to further discoveries about the universe. Since ancient times, astronomers had believed that the moon, planets, and stars were all perfect, unchanging bodies.

Through the telescope, Galileo saw that the moon had a rough surface broken by jagged mountains. He discovered that the planet Jupiter had four moons, which no one had seen before. The sun was seen to be imperfect because it had dark, changeable spots on its surface. Galileo's discoveries showed that the universe was very different from what ancient philosophers had taught.

Galileo on Trial

When Galileo announced his discoveries in the early 1600s, the conflict between traditional thinking and the new science broke into the open. Galileo offended many scien-



The telescope made possible more detailed observation of the sky than ever before. This painting shows two Italians examining the moon's surface through a telescope made by Galileo. Through his telescope, Galileo observed that the moon had a rough surface. He also discovered that the Milky Way, once thought to be a kind of heavenly mist, was in fact a vast belt of stars.

tists by declaring that the heavenly bodies were imperfect and changing. An outspoken man, he did not hesitate to defend his views. He made powerful enemies when he humiliated his critics in public.

These enemies convinced the Catholic Church to condemn the teachings of Copernicus and to forbid Galileo from defending the new ideas. When Galileo refused to obey, church officials called him before the Inquisition. They demanded that he publicly admit his error. In order to avoid being condemned as a heretic and face death, Galileo declared at the trial that the earth stood motionless at the center of the universe. But as

he left the court after the trial, Galileo whispered softly under his breath, "And yet it moves."

Newton and Natural Laws

An English mathematician, Sir Isaac Newton, built on the work of many earlier scientists. In 1687, Newton published *The Mathematical Principles of Natural Philosophy*. In this book, he provided mathematical proofs of what people such as Kepler and Galileo had observed. Newton invented calculus, a method of calculation, which he used to prove his theories.

Among Newton's most important contributions to science was the law of gravity, which he wrote as a mathematical formula. Newton's *law of gravity* states that there is a force of attraction between objects that increases as objects move closer together. Newton's law explains mathematically how the moon's gravity causes tides on the earth and how the sun's gravity keeps the planets within their orbits. Newton is said to have developed the law of gravity after he saw an apple fall. He wondered why it fell to the ground and did not fly into space. His law explains that an apple falls to the ground because it is attracted by the earth's gravity.

Newton's work helped to develop a new view of the universe. Newton saw the universe as a huge, well-regulated machine that worked according to definite laws of nature, such as the law of gravity.

Newton's work had many effects. Navigators and mapmakers used his mathematics to make more precise charts. Calculus was used to improve weapons such as guns and cannons. Later, inventors improved on Newton's ideas and developed such practical devices as the steam engine.

Improvements in Medicine

During the 1500s and 1600s, scientists made significant advances in medicine. Some challenged the theories of Galen, a Greek physician whose work had dominated medicine in the Middle Ages.

In the early 1500s, a Swiss physician known as Paracelsus (PAR uh SEHL suhs) experimented with chemistry. He disproved

Galen's idea that chemical changes, such as transforming one substance into another, were impossible. He produced distilled liquids that he used as medicine.

At the University of Padua in Italy, scholars studied the human body. In 1543, Andreas Vesalius (vih SAY lee uhs), a professor of anatomy, wrote *On the Structure of the Human Body*. He made accurate drawings of the human anatomy that corrected some of Galen's errors.

A French physician, Ambroise Paré (pah RAY), studied Vesalius' textbook and soon made his own contributions to medicine. Traditionally, doctors had tried to prevent infection in wounds by pouring boiling oil into the wound, an extremely painful remedy. Paré developed an ointment that could be applied instead. Later, Paré also developed a technique for closing wounds with stitches.

In the early 1600s, an Englishman, William Harvey, studied the circulation of the blood through the body and showed that the heart acted as a pump to circulate blood through arteries and veins. Traditionally, doctors had thought that blood remained stationary.

The work of these physicians and others resulted in further medical breakthroughs. In the 1700s, for example, doctors learned how to produce a vaccine that could be used to prevent smallpox. As medical and scientific knowledge increased, scholars formed scientific societies to exchange information.

SECTION REVIEW

1. Identify: Nicolaus Copernicus, Tycho Brahe, Johannes Kepler, Galileo Galilei.
 2. Define: scientific method, law of gravity.
 3. Why was mathematics important to the scientific method?
 4. Give two reasons why scholars challenged the ideas of Copernicus.
 5. What did Galileo's observations through the telescope reveal?
 6. How did Newton think the universe worked?
 7. Describe one way each of the following contributed to medical knowledge: (a) Paracelsus, (b) Andreas Vesalius, (c) Ambroise Paré, (d) William Harvey.
-