

CHAPTER 6

SCIENCE, LEARNING, AND SOCIETY

6.1 THEMES

The scientific revolution of the sixteenth and seventeenth centuries replaced religion as the explanation for the occurrences of the physical world. In contrast to religious articles of faith, the approach of science relied on experiment and mathematics. Learning, including the arts, moved away from Renaissance models to emphasize the emotions and individual variations.

While the family as an institution remained unchanged, much of society was transformed by population growth, inflation, and new patterns of landholding, trade, and industry.

6.2 THE SCIENTIFIC REVOLUTION

6.2.1 *Astronomy*

Astronomy, and to a lesser degree physics, first produced the new ways of thought called the scientific revolution.

Middle Ages. The ideas of the ancient Greek Aristotle (384 – 22 B.C.) provided the system of explanations. Aristotle believed the motionless earth occupied the center of the universe, and the sun, planets, and stars revolved around it in circular orbits determined by crystalline spheres. Aristotle's system was further refined by Ptolemy, a second-century astronomer, to make it correspond to the observed movements of the stars and planets.

Nicolaus Copernicus (1473 – 1543). Accepting the Aristotelian idea that the circle is the closest to the perfect figure and the Renaissance belief in simple explanations, Copernicus suggested that the sun was at the center of the universe and that the earth and planets revolved around it in circular orbits. His *On the Revolutions of the Heavenly Spheres* was published in 1543, the year of his death. Copernicus' ideas meant the universe was immense, removed people from occupying the center of the universe to inhabiting a small planet in a vast system, and eliminated distinctions between the earth and the heavens.

Copernicus' views were not immediately accepted because they contradicted the words of the Bible and, as he posited circular orbits for the planets, did not accurately predict their locations.

Tycho Brahe (1546 – 1601). A Danish nobleman, Brahe built the best observatory of his time and collected extensive data on the location of the stars and planets. Brahe did not totally accept Copernicus' views as he believed that the earth

still occupied the center of the universe but that the other planets revolved around the sun, which, in turn, revolved around the earth.

Brahe's discovery of a new star in 1572 and the appearance of a comet in 1577 shattered beliefs in an unchanging sky and crystalline spheres.

Johannes Kepler (1571 – 1630). Kepler's reworking of Copernicus' theory and Brahe's observations produced the idea that the planets move around the sun in elliptical, not circular, orbits. The three new laws of Kepler accurately predicted the movements of the planets and were based on mathematical relationships.

Galileo (1564 – 1642). Galileo discovered four moons of Jupiter using a telescope, a new invention of the time. He also conducted other experiments in physics related to the relationship of movement of objects and the mathematics necessary to describe the movement, such as that of the pendulum.

A propagandist for science, Galileo defended his discoveries and mocked his opponents. The Catholic Church in Italy, where Galileo lived and worked, forced him to recant his views, which demonstrated the conflict of the older religious views and the new scientific approach.

6.2.2 *Scientific Methodologies*

Francis Bacon (1561 – 1626). The author of *Advancement of Learning* (1605) and an advocate of experimental approaches to knowledge, Bacon formalized empiricism, an approach using inductive reasoning. An Englishman, Bacon himself did few experiments but believed empiricism would produce useful, not only theoretical, knowledge.

Rene Descartes (1596 – 1650). Beginning from basic principles, Descartes believed scientific laws could be found by deductive reasoning. Formulating analytic geometry, Descartes knew that geometry and algebra were related and that equations could describe figures. Later developments merged inductive experimentalism with deductive, mathematical rationalism to produce today's epistemology, the methods to obtain and verify knowledge.

6.2.3 *Connections with the Rest of Society*

During the Renaissance many universities established the study of mathematics and physics. All the great scientists involved in the changes in astronomy studied at universities.

The demands of the explorers, especially those at sea, for more accurate measurements of the stars increased attention on the details of the heavenly movements.

Warfare, particularly the developing use of artillery, required and permitted explanations involving precise measurements.

Initially, Protestant areas were more hostile than Catholic ones to the new learning, but after Galileo, Catholic authorities led in trying to suppress the new ideas.

6.2.4 *Consequences*

The new approaches of the scientific method spread to inquiries far beyond astronomy and physics. Many sought new explanations as well as order and uniformity in all aspects of the physical world and society.

William Harvey (1578 – 1657), demonstrated the circulation of blood and the role of the human heart. Thomas Hobbes (1558 – 1679), an English writer on political theory, studied

society and, using a few basic premises, described politics in *Leviathan* (1651).

Blaise Pascal (1623 – 62), a French mathematician and scientist, developed several new ideas, including the basis for calculus, but worried about the increasing reliance on science which he believed could not explain the truly important things of life; these could only be perceived by faith. Human beings, which had been at the center of the universe and the central link in the Great Chain of Being, became merely creatures in an unintelligibly vast universe.

Scientists slowly replaced the clergy as the people able to explain the happenings of the physical world. However, few of the discoveries—except for the aids to explorers—had any consequences on the lives of Europeans.

6.3 LITERATURE AND THE ARTS

6.3.1 *Literature*

Cervantes (1647 – 1616). Cervantes, a Spaniard, was a former soldier and slave concerned with the problems of religious idealism. *Don Quixote* (1605) satirized chivalric romances and described a worldly-wise, skeptical peasant (Sancho Panza) and a mentally unstable religious idealist (Don Quixote).

William Shakespeare (1564 – 1616). Mixing all aspects of English life in the years around 1600—country, court, Renaissance ideas—Shakespeare wrote tragedies, comedies, histories, and sonnets. Besides a gift for psychological studies of his characters and the timelessness of his themes, Shakespeare used the English language in new ways which permanently altered it.

John Milton (1608 – 1674). Influenced by the Renaissance while travelling in Italy, the Englishman Milton also had strong Puritan religious beliefs. *Paradise Lost* studied the motives of those who reject God. Milton took an active part in the troubles in England from 1640 to 1660 as a secretary to a committee of Parliament.

Michel de Montaigne (1533 – 92). A Frenchman, Montaigne became obsessed with death and the problems it raised. The inventor of the form of the essay, he adopted skepticism, doubting that true knowledge can be obtained, before turning to a belief in the value of individual self-study.

6.3.2 *The Arts*

Mannerism. Rejecting the balance and calm of Renaissance arts, Mannerists, who dominated painting and sculpture in the latter part of the sixteenth century, emphasized dramatic and emotional qualities. El Greco (1541 – 1614), a Greek who lived in Spain, took Mannerist qualities to the extreme.

Baroque. In the seventeenth century artists attempted to involve the viewer by emphasizing passion and mystery as well as drama. Baroque, which emphasized grandeur, was connected with the Counter Reformation and monarchies, and was found primarily in Catholic countries.

The works of Bernini (1598 – 1680), such as his *David*, capture the appeal to emotion, the sense of tension in the object, and the human energy of their subjects. Rubens (1577 – 1640), painting both religious and secular themes, conveyed the strength and majesty of his subjects.

In music, Monteverdi (1647 – 1643), using many new instruments such as strings and woodwinds, wrote *Orfeo* (1607) and is known as the creator of the opera and the orchestra.

Later in the seventeenth century, architecture, especially that of palaces, displayed the forces of power by adopting baroque forms.

6.4 SOCIETY

6.4.1 *Hierarchy*

A system whereby people, usually as members of groups, are ranked from highest to lowest in terms of power, wealth, or status became the dominant view in the Europe of the sixteenth and seventeenth centuries.

Two major hierarchies existed: the countryside and the cities. Rural hierarchy consisted of landlords, peasants, landless laborers. Urban hierarchy was comprised of merchants, artisans, laborers. Clergy, lawyers, teachers, and civil servants fit somewhat awkwardly in both hierarchies.

New and expanding groups relied on education or wealth to join older groups. People seeking to join the aristocracy often sought education as a means of acquiring noble status and behavior. Wealth permitted an artisan to become a merchant or, after a generation or two, a rich peasant to become a noble. The advantages of being in a higher group, besides the status, could include separate taxes and exemption from some taxes.

Social mobility—the changing from one group to another—was not accepted in the writings of the day but did occur, though it was very hard to measure.

6.4.2 *Demography*

Exact numbers concerning population are not possible, as complete censuses do not exist. Following the Black Death and

its repeated appearances in the fourteenth century, the population remained stagnant. Population began growing again in the sixteenth century and continued its upward climb until about 1650 when it levelled off for another century. The population of Europe nearly doubled between 1500 and 1650.

The population (very approximate) of some European countries in 1650 can be estimated at the following levels:

England	5.5 million
France	18.0 million
Holy Roman Empire	11.0 million
Italian peninsula	12.0 million
Spain	5.2 million
Sweden	1.5 million
United Provinces	1.5 million

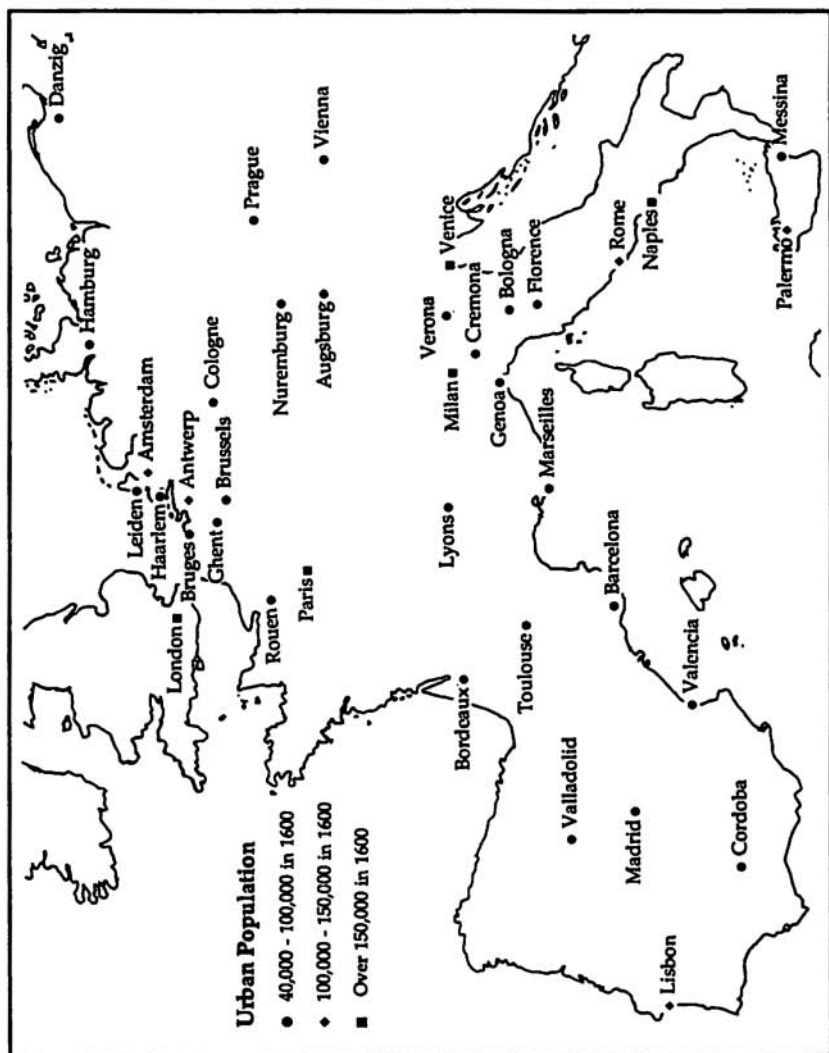
Cities grew much faster than the population as a whole as people migrated from the countryside. London grew from 50,000 in 1500 to 200,000 in 1650. Cities contained perhaps 10 to 20 percent of the total population of Europe.

Though historians and demographers are not certain, population probably grew because of slight declines in the average age of marriage and better nutrition, not better medicine.

6.4.3 *The Family*

The majority of households consisted of what is today referred to as the nuclear family. Fifty percent of the babies born

EUROPEAN CITIES IN 1600



in the sixteenth century didn't reach their first birthday, and those who survived were often killed by disease, famine, or war. The average age of marriage was approximately 27 for men and 25 for women, though the nobility married younger. Few people married early enough or lived long enough to see their grandchildren.

The theory of family relationships, as expressed in sermons and writings, was one of patriarchy, with the father and husband responsible for and in command of the rest of the family. The reality of family relationships was more complex and, due to lack of sources, is not clear to historians.

Romantic love did exist, especially after marriage, but historians disagree as to whether it was the dominant element in forming marriages. Women, particularly in urban areas, shared in the work of their artisan and merchant husbands but rarely operated a business on their own.

Divorce was very rare, making for theoretically stable family units.

6.4.4 *Witchcraft*

Witch-hunting, though found in the late Middle Ages, occurred primarily in the sixteenth and seventeenth centuries. Belief in witches was found among all walks of life—the educated, the religious, the poor.

Historians and anthropologists provide many explanations as to why people believed in witches and why witch-hunting occurred when and where it did. For one thing, the least powerful members of society are vulnerable to scapegoating. For another, women—especially those not living under the control and protection of men—were largely defenseless against charges of witchcraft. Many historians believe that widows were the

group most often accused of witchcraft because they were experienced sexually yet not under the direct control of a man. The combination of sexual experience and relative freedom was threatening to many people. This societal repression of sexuality led to the projection of sexual fears and hopes onto women, who were then punished for this perceived aberrance by being accused of witchcraft.

Another contributing factor is that the increased concern with religion after the Reformation focused more attention on the role of the devil in life.

Historically, women have been viewed as the more bodily of the two sexes and were therefore considered to be more open to the temptation of the devil.

6.4.5 *Food and Diet*

Bread was the staff of life and the chief item in the diet of the laboring classes. Vegetables included peas and beans, as the vegetables from the Americas were not widely used by 1650. Meat and eggs were saved for special occasions except among the richer elements of society. Beverages included beer and wine as milk was considered unhealthy except for the young.

Nobles and the bourgeoisie ate lots of rich meats and fish with cheeses and sweets, but few vegetables or fruit. The English ate better than the rest of Europe, with the peoples of the Mediterranean areas eating the worst.

Local famines were still common as governments lacked the ability to move food from an area of surplus to one of dearth.

6.4.6 *The Economy*

Inflation, sometimes called the price revolution, began around 1500 and continued until about the middle of the seventeenth century. Foodstuffs rose in price tenfold. The rise in population was the primary cause of the inflation as there were more mouths to feed than food available. Another possible cause was the flow of silver from the Americas which increased the amount of money available to buy things.

Farmers sought to increase output as the price of food rose. Land was brought under cultivation, which had been idle since the Black Death of 1348. In England, enclosures, which resulted in fewer people living on the land, produced larger, more efficient farms. In Eastern Europe, landlords turned their lands into large wheat exporting operations and began the process of converting the peasants and laborers into serfs.

Trade and industry. Trade grew, both with the rest of the world and within Europe. Certain areas began to specialize: for example, the lands south and east of the Baltic produced wheat for northwestern Europe. The Dutch fleet dominated European trade.

The textile industry, the chief industry of Europe since the Middle Ages, underwent change. Regional specialization occurred on a larger scale. The putting-out system appeared whereby the industry moved out of the cities into the countryside and the process of production was divided into many steps with different workers doing each step.

6.4.7 *Mercantilism*

The conscious pursuit by governments of policies designed to increase national wealth, especially of gold, became common

in the seventeenth century. The chief aim was to obtain a favorable balance of international payments. Governments sought to create industries in order to avoid importing items.