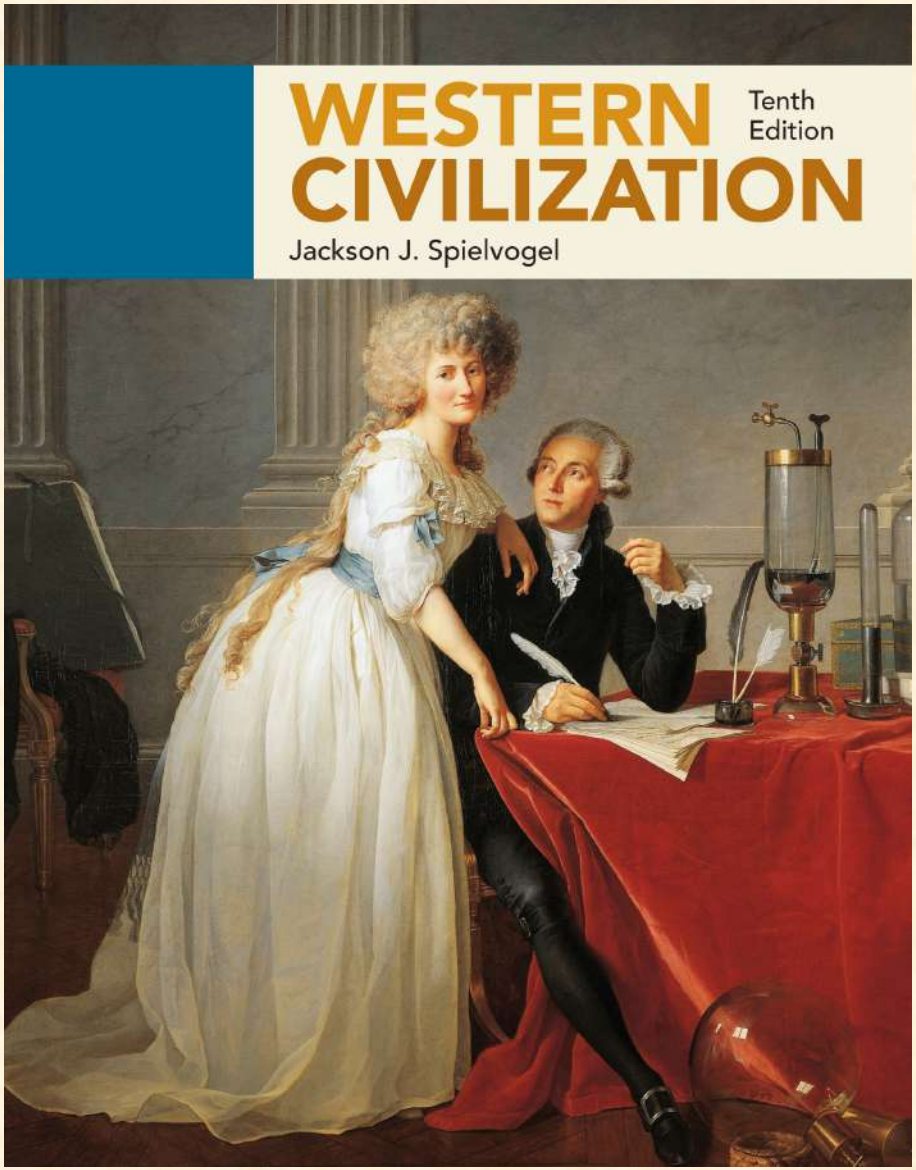


Chapter 16

Toward a New Heaven and a New Earth: The Scientific Revolution and the Emergence of Modern Science

CENGAGE

Focus Questions

- What developments during the Middle Ages and the Renaissance contributed to the Scientific Revolution of the seventeenth century?
- What did Copernicus, Kepler, Galileo, and Newton contribute to a new vision of the universe, and how did it differ from the Ptolemaic conception of the universe?
- What did Paracelsus, Vesalius, and Harvey contribute to a scientific view of medicine?
- What role did women play in the Scientific Revolution?
- Why is Descartes considered the “founder of modern rationalism”?
- How were the ideas of the Scientific Revolution spread, and what impact did they have on society and religion?

A nineteenth-century painting of Galileo before the Holy Office in the Vatican in 1633

Louvre, Paris//Erich Lessing/Art Resource, NY

Background to the Scientific Revolution

- Ancient Authors and Renaissance Artists
  - Limitations in the perspectives of medieval scientists
  - The Renaissance and ancient knowledge
    - Contradictions of medieval authorities
    - Close observation of nature
    - Perspective and anatomical proportions
- Technological Innovations and Mathematics
  - Tensions between technology and Scientific Revolution
  - Mathematics regarded as key to understanding
- Renaissance Magic
  - Hermetic magic and alchemical thought

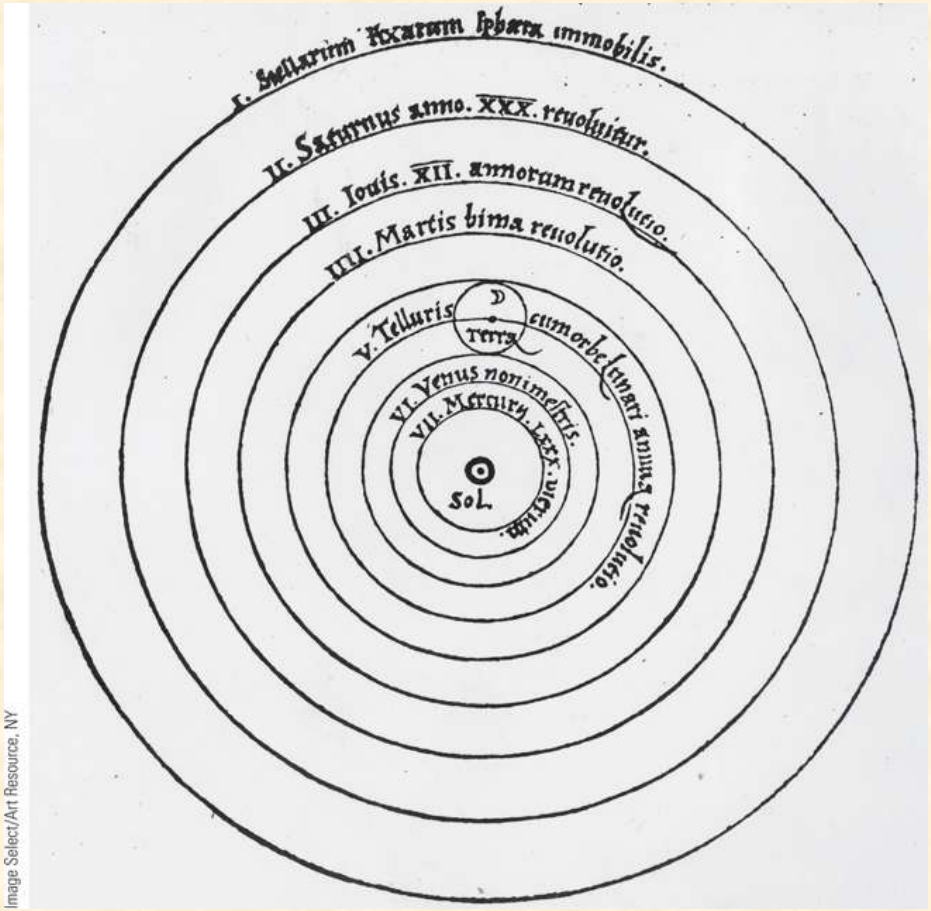
Toward a New Heaven: A Revolution in Astronomy (Slide 1 of 2)

- Medieval Cosmological Views
  - Based on Aristotle, Ptolemy, and Christian theology
  - Geocentric conception
    - Concentric spheres with fixed earth at center
  - Nicolaus Copernicus (1473 – 1543)
  - *On The Revolution of the Heavenly Spheres*
    - Observation and heliocentric conception
      - The conservatism of Copernicus
    - Creates doubt about the Ptolemaic system

Medieval Conception of the Universe

As this sixteenth-century illustration shows, the medieval cosmological view placed the earth at the center of the universe, surrounded by a series of concentric spheres.

The Copernican System

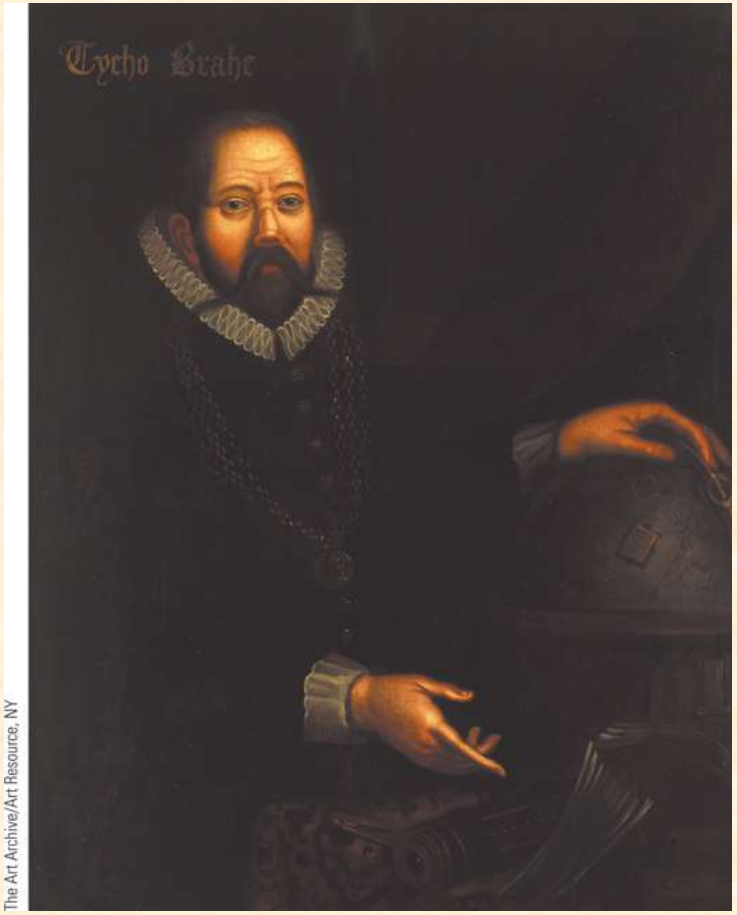


As shown in this illustration from the first edition of the book, Copernicus maintained that the sun was the center of the universe and that the planets, including the earth, revolved around it.

Toward a New Heaven: A Revolution in Astronomy (Slide 2 of 2)

- Tycho Brahe (1546 – 1601)
  - Uraniborg Castle
  - Rejected Aristotelian-Ptolemaic system
- Johannes Kepler (1571 – 1630)
  - Hermetic thought and mathematical magic
  - Laws of planetary motion
    - Discrediting the Aristotelian-Ptolemaic system
    - Eliminating the idea of uniform circular motion
- Galileo Galilei (1564 – 1642)
  - The telescope and *The Starry Messenger*
  - Galileo and the Inquisition
  - Problem of motion; principle of inertia

Tycho Brahe



The Art Archive/Art Resource, NY

Brahe's work at the Uraniborg observatory provided astronomers with the best data on the position of the celestial bodies.

The Telescope (Slide 1 of 2)

The invention of the telescope enabled Europeans to inaugurate a new age in astronomy. Shown here is Johannes Hevelius, an eminent German-Polish astrologer (1611–1697), making an observation with his telescope.

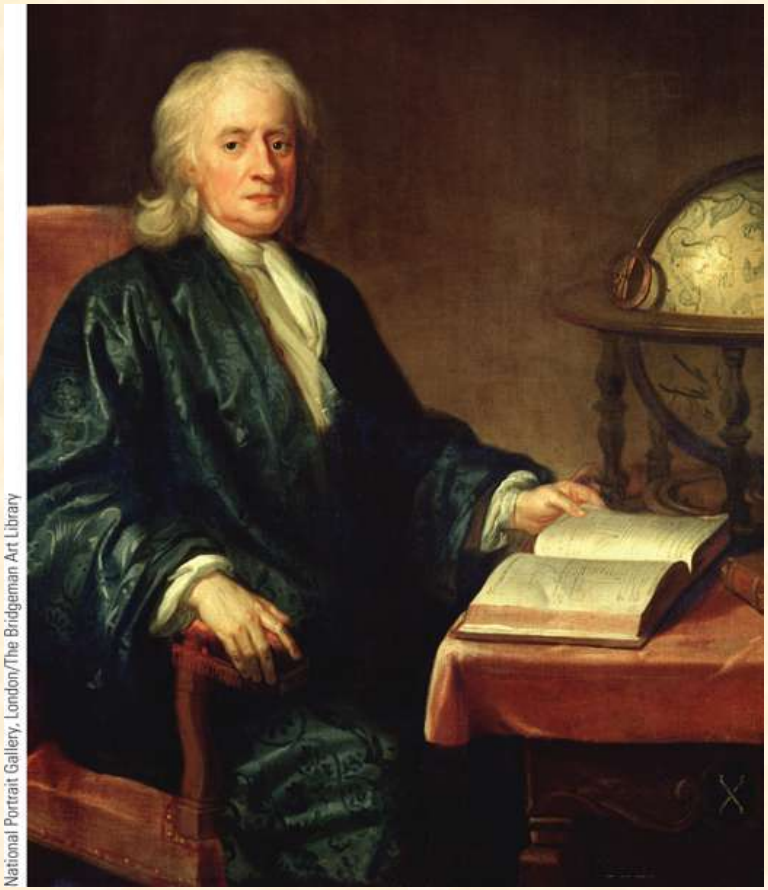
The Telescope (Slide 2 of 2)

The photograph above shows Galileo's original telescope, built in 1609.

Isaac Newton (1642 – 1727)

- Early Achievements
  - Invention of calculus
  - *Mathematical Principles of Natural Philosophy, or Principia* (1684 – 1686)
- Newton and the Occult
- Universal Law of Gravitation
  - A new cosmology
    - Three laws of motion
    - Consequences: world seen in mechanistic terms
      - God and Newton's world-machine

Isaac Newton



With a single law, that of universal gravitation, Isaac Newton was able to explain all motion in the universe.

CHRONOLOGY Important Works of the Scientific Revolution

Work	**Dates**
Copernicus, *On the Revolutions of the Heavenly Spheres*	1543
Vesalius, *On the Fabric of the Human Body*	1543
Galileo, *The Starry Messenger*	1610
Harvey, *On the Motion of the Heart and Blood*	1628
Galileo, *Dialogue on the Two Chief World Systems*	1632
Cavendish, *Grounds of Natural Philosophy*	1668
Newton, *Principia*	1687

Advances in Medicine and Chemistry

- Galenic hypotheses; purging and bleeding; herbal medicines
- Paracelsus (1493 – 1541)
  - Rejection of Aristotle and Galen
  - The macrocosmic-microcosmic principle
- Andreas Vesalius (1514 – 1564)
  - *On the Fabric of the Human Body* (1543)
    - Based on dissection of a human body
- William Harvey (1578 – 1657)
  - *On the Motion of the Heart and Blood* (1628)
- Chemistry
  - Robert Boyle (1627 – 1691)
  - Antoine Lavoisier (1743 – 1794)

Andreas Vesalius

In this seventeenth-century French portrait of Andreas Vesalius, Vesalius is portrayed with one of his cadavers.

Women in the Origins of Modern Science

- Margaret Cavendish (1623 – 1673)
  - *Observations upon Experimental Philosophy*
  - *Grounds of Natural Philosophy*
  - Attacks on rationalist and empiricist approaches to scientific knowledge
- Maria Sibylla Merian (1647 – 1717)
  - Entomology and the craft tradition
- Maria Winkelmann (1670 – 1720)
  - Achievements in astronomy
  - Difficulties with the Berlin Academy

Margaret Cavendish

Shown in this portrait is Margaret Cavendish, the duchess of Newcastle. She was a prolific writer, responsible for plays, biographies, poetry, and prose romances, as well as works in philosophy and science.

Debates on the Nature of Women

- The *Querelles des Femmes*
  - Tradition: women as inherently base, prone to vice, easily swayed, and "sexually insatiable"
  - Challenges to tradition
    - Women joined debate in the 17th century, rejecting this view
  - The impact of science
    - The new anatomy
    - Women's loss of traditional spheres of influence
    - Reaffirmation of traditional ideas about the nature of women

Toward a New Earth: Descartes, Rationalism, and a New View of Humankind

- Rene Descartes (1596 – 1650)
  - Reflections on doubt and uncertainty
  - *Discourse on Method* (1637)
    - "I think, therefore I am."
  - Separation of mind and matter
    - Cartesian Dualism
  - Consequences: the birth of modern rationalism

Descartes

Rene´ Descartes was one of the primary figures in the Scientific Revolution.

The Scientific Method and the Spread of Scientific Knowledge

- The Scientific Method
  - Francis Bacon (1561 – 1626)
    - Rejection of Copernicus and Kepler; Misunderstanding of Galileo
    - *The Great Instauration* and correct scientific method
      - Built on inductive principles, proceeding from the particular to the general
      - Experimentation and domination of nature
  - Descartes
    - Deduction and mathematical logic
    - Newton's unification of Bacon's empiricism and Descartes rationalism

Louis XIV and Colbert Visit the Academy of Sciences

Chateaux de Versailles et de Trianon (Gérard Blot), Versailles//© RMN-Grand Palais/Art Resource, NY

In the seventeenth century, individual scientists received royal and princely patronage, and a number of learned societies were established.

Images of Everyday Life: The Science of Collecting (Slide 1 of 3)

Various beetles and arachnids

Images of Everyday Life: The Science of Collecting (Slide 2 of 3)

Sir Hans Sloane

Images of Everyday Life: The Science of Collecting (Slide 3 of 3)

French Royal Botanical Garden

The Scientific Method and the Spread of Scientific Knowledge (Slide 1 of 2)

- The Scientific Societies
  - English Royal Society
    - Informal meetings at London and Oxford
    - Received formal charter in 1662 from Charles II
  - French Royal Academy
    - Informal meetings in Paris
    - Formally recognized by Louis XIV (1666)
  - Contributions
    - Recognition of the practical value of scientific research
    - Focus on theoretical work in mechanics and astronomy

The Scientific Method and the Spread of Scientific Knowledge (Slide 2 of 2)

- Science and Society
  - People recognized science's rational superiority
  - Economic implications
    - Science offered new ways to exploit resources for profit
      - Science as a part of elite culture
  - Political implications
    - Linking the scientific conception of the natural world to social stability
    - Patronage to bolster military applications

Science and Religion

- Tensions between Science and Religion
- Benedict de Spinoza (1632 – 1677)
  - Philosophy of pantheism (monism)
  - Reason creates happiness and freedom
- Blaise Pascal (1623 – 1662)
  - Sought unity of science and religion
  - *Pensées* (Thoughts)
    - Sought to convert rationalists to Christianity
  - Christianity not contrary to reason
  - Reason had limits

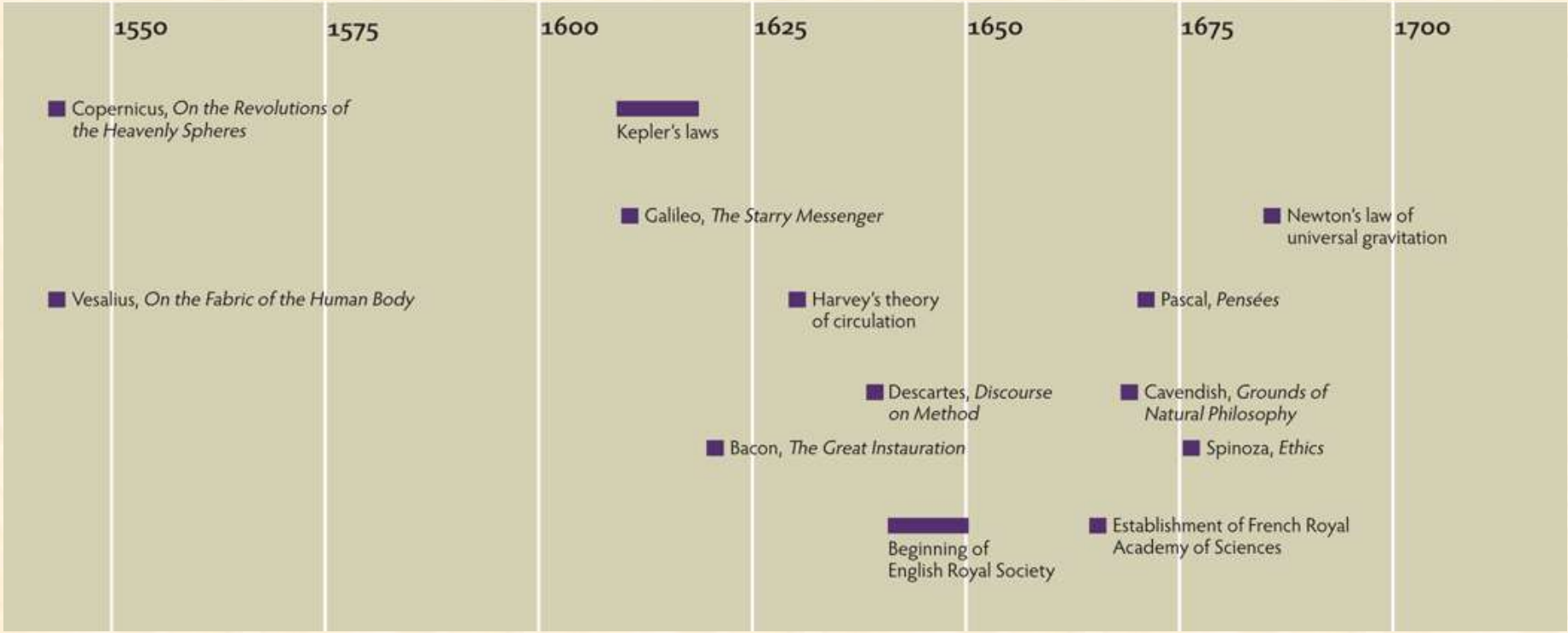
Blaise Pascal

Blaise Pascal was a brilliant scientist and mathematician who hoped to keep science and Christianity united.

CHRONOLOGY Consequences of the Scientific Revolution: Important Works

Work	**Dates**
Bacon, *The Great Instauration*	1620
Descartes, *Discourse on Method*	1637
Pascal, *Pensées*	1669
Spinoza, *Ethics Demonstrated in the Geometrical Manner*	1677

Chapter Timeline



Discussion Questions

- How did the Middle Ages and the Renaissance contribute to the Scientific Revolution?
- Why were advances in mathematics so important during the Scientific Revolution?
- Why did religious leaders react so negatively to the new advances in Science, especially in astronomy?
- Why is Newton's *Principia* called the "hinge point of modern scientific thought"?
- How did women come to play such an important role in the Scientific Revolution?
- Why did scientific societies refuse to recognize women involved in the sciences?