

## Chapter 6: Enlightenment and Revolution 1550-1789

### What's going on in the world at this time?

- 1543: Copernicus publishes heliocentric theory
- 1556: Golden Age of Mughal Empire begins in India
- 1603: Tokugawa Ieyasu becomes ruler of all Japan
- 1609: Galileo observes the heavens through a telescope
- 1644: Manchus invade China and establish the Qing dynasty
- 1687: Newton publishes his treatise on gravity
- 1706: Act of Union, creating the United Kingdom
- 1776: American colonies declare independence from Britain
- 1789: French Revolution begins with the storming of the Bastille

### Section 1: The Scientific Revolution

#### Introduction:

- Review: The period from 1300-1600 was a time of great change in Europe. The Renaissance inspired curiosity in many fields.
- The Protestant Reformation prompted followers to challenge accepted ways of thinking about God and salvation.
- It was also at this time that a third revolution was forming... one that would change how people viewed the physical world.

#### The Roots of Modern Science:

- Before 1500, most scholars decided what was true or false by referring to an ancient Greek/Roman text or the Bible. Few observed and tested for themselves.
- During the Middle Ages, most scholars believed in Ptolemy's **geocentric theory**, which stated that Earth was an immovable object at the center of the universe. The sun, moon and all the other planets moved in perfectly circular paths around the earth.
- Aristotle created the idea, Ptolemy expanded it and Christianity at that time preached that God had deliberately placed the earth at the center of the universe.

- The **Scientific Revolution** was a new way of thinking about the natural world. That way was based upon careful observation and a willingness to question accepted beliefs.
- Scientific method did not develop overnight. It took two men, **Francis Bacon** and **Rene Descartes** to help advance this new approach.
- Bacon, an English scientist and writer, developed **empiricism**, or experimental method. Instead of reasoning from abstract theories, he urged scientists to experiment and then draw conclusions.
- Descartes, a French scientist and philosopher, developed analytical geometry which linked algebra and geometry.
- He relied on mathematics and logic, believing that everything should be doubted until proved by reason.
- Modern methods are based on a combination of both men's methods: observation, experimentation and general laws that can be expressed mathematically.
- In the mid 1600s, the work of Copernicus, Kepler and Galileo had shattered the old ideas in astronomy and physics.
- Later, Newton helped bring together their breakthroughs under a single theory of motion.
- By the time he was 26, Newton was certain that all physical objects were affected equally by the same forces.
- His great discovery was that the same force ruled motion of the planets, all matter on earth and in space. The key idea that linked motion in the heavens with the motion on earth was the **law of universal gravitation**.
- According to this law, every object in the universe attracts every other object. The degree of attraction depends on the mass of the objects and the distance between them.
- In 1687, Newton published his ideas in the book *The Mathematical Principles of Natural Philosophy*.

### The Scientific Revolution Spreads

- Scientists discovered new tools and instruments to make the precise observations that the scientific method demanded.
- The first microscope was invented by Zacharias Janssen in 1590. Previously, Janssen made eyeglasses.
- Anton van Leeuwenhoek used the microscope to observe and examine bacteria and red blood cells.

- In 1643, Evangelista Torricelli (a student of Galileo's) created the first mercury barometer, a tool for measuring atmospheric pressure and for predicting weather.
- 1714: Gabriel Fahrenheit made the first mercury/glass thermometer. His thermometer showed water freezing at 32 degrees.
- 1742: Anders Celsius's scale for the thermometer showed water freezing at 0 degrees.

### Medicine and the Human Body

- In the Middle Ages, physicians depended on the works of the ancient Greek doctor, Galen.
- Galen, however, had only studied pig anatomy and had never dissected the body of a human being. He assumed that pig and human anatomies were comparable.
- A Flemish doctor named Andreas Vesalius proved Galen wrong. Vesalius dissected corpses and published his findings.
- His book, *On the Structure of the Human Body*, was filled with detailed drawings.
- In the late 1700s, Edward Jenner of England introduced a smallpox vaccine. It was based on the cowpox virus and gave humans permanent resistance to smallpox.

### Discoveries in Chemistry

- Robert Boyle pioneered the use of scientific method in chemistry. He is considered the founder of modern chemistry.
- In his book *The Sceptical Chymist*, Boyle challenged Aristotle's idea that the physical world consisted of only 4 elements. Boyle proposed that matter was made up of smaller primary particles that joined together in different ways.
- His most famous contribution is Boyle's Law, which states how the volume, temperature and pressure of a gas affects each other.
- The ideas of reason and order, which spurred so many breakthroughs in science, soon moved in to other fields of life. Scientific thinking reformed other areas of everyday life, including politics.