3.4 The Impact of the Reformation

The Reformation resulted in a cultural shift. Once people could interpret the Bible for themselves, they formed new ideas about the Christian religion. More Protestant denominations formed as differences in beliefs developed, and new Protestant churches sprang up. Europe would never be the same.

MAIN IDEA

The Reformation had a long-lasting religious, social, and political impact on Europe.

RELIGIOUS EFFECTS

Protestantism flourished. Like Catholics, Protestants founded universities and parish schools to teach their beliefs and gain new followers. As a result, because both Protestants and Catholics wanted to read the Bible, the Reformation increased literacy.

In England, many Anglicans learned to read the Bible but not in the vernacular. They followed the Catholic belief that prohibited reading the Bible in translation. However, reformer William Tyndale believed that Anglicans should reject all Catholic beliefs and practices and so began to prepare an English translation of the New Testament. Tyndale completed his work in Germany. In time, however, Catholic officials there arrested and executed him for his beliefs.

POLITICAL EFFECTS

The Reformation had both positive and negative political effects. On the positive side, the Reformation influenced the development of democracy and federalism. Protestants who formed a church sometimes governed it themselves. This practice would later encourage religious groups immigrating to the English colonies to form a government with equal and fair laws—an early step toward democracy. In addition, Calvinist churches sometimes allowed church members to share power with the clergy. This practice represented an early form of federalism in which power is shared, like that between a national government and state governments.

On the negative side, the Reformation led to widespread warfare in Europe. In the years after Luther published the 95 Theses, religious wars erupted within countries and between them. The Thirty Years' War, for example, started as a conflict between Catholics and Protestants in Central Europe. The war, which lasted from 1618 to 1648, devastated the German states, killing an estimated seven million people.

Although the Catholic Church had partly recovered from the Reformation, its power in Europe would come to be challenged by powerful kings. These kings worked to bring all of the people within their territory under a unified rule. As a result, powerful modern **nation-states** began to emerge, with their own independent governments and populations united by a shared culture, language, and national pride.

The Catholic Church would also face challenges from another source. Scientists influenced by humanism would begin to question accepted views—including those of the Church. Their discoveries would change the way people looked at the world

Church towers in the northern European country of Latvia represent three different Christian denominations: (from left to right) Lutheranism, Catholicism, and Anglicanism.

REVIEW & ASSESS

1. **READING CHECK** What were some of the religious effects of the Reformation?

2. **DETERMINE WORD MEANINGS** In the sentence "Because more people wanted to read the Bible, the Reformation also increased literacy," what does *literacy* mean?

3. **ANALYZE CAUSE AND EFFECT** What led to the rise of nation-states?

7.9.3 Explain Protestants' new practices of church self-government and the influence of those practices on the development of democratic practices and ideas of federalism; HI 2 Students understand and distinguish cause, effect, sequence, and correlation in historical events, including the long- and short-term causal relations.

CHAPTER 13

THE AGE OF SCIENCE AND EXPLORATION

1400 – 1700

ESSENTIAL QUESTION How did new ideas affect Europeans' views of the world?

SECTION 1 THE SCIENTIFIC REVOLUTION

KEY VOCABULARY
elliptical
geocentric theory
heliocentric theory
hypothesis
scientific method
scientific rationalism
theory

NAMES & PLACES
Galileo Galilei
Isaac Newton
Nicolaus Copernicus
René Descartes
Robert Hooke
Scientific Revolution
Sir Francis Bacon

SECTION 2 THE AGE OF EXPLORATION

KEY VOCABULARY
caravel
colony
exploit
quinine
rivalry
smallpox

NAMES & PLACES
Christopher Columbus
Columbian Exchange
Dutch East India Company
Ferdinand and Isabella
Prince Henry the Navigator

SECTION 3 EUROPEAN EMPIRES

KEY VOCABULARY
conquistador
cottage industry
mercantilism
plantation
racism
triangular trade

NAMES & PLACES
Atahualpa
Francisco Pizarro
Hernán Cortés
Middle Passage
Pedro Álvares Cabral
Tenochtitlán

READING STRATEGY

MAKE INFERENCES
When you make inferences, you "read between the lines" to find information that isn't stated directly. As you read the chapter, use a chart like this one to make inferences about the relationship between the Scientific Revolution and European exploration.

I Learned	My Inference

A giant collection of telescopes in Chile scans the night sky. During the Age of Exploration, observations of the stars and planets led to changes in scientific views of the universe.

1.1 Roots of the Revolution

The period following the Middle Ages was one of major changes in Europe. The Renaissance brought an explosion of creativity in art, literature, and architecture. The Reformation transformed people's religious ideas. Another important movement introduced great advances in science. This movement is called the **Scientific Revolution**, and it began in Europe around the mid-1500s.

MAIN IDEA

Before the Scientific Revolution, Europeans generally relied on the works of ancient Greek thinkers and medieval Muslim scholars to answer scientific questions.

ANCIENT GREEK SCIENTISTS

Since earliest times, people have attempted to understand and explain the natural world—sometimes through religion, sometimes through science, and sometimes by combining the two. Early scientists called themselves "natural philosophers," and their methods differed greatly from those of modern scientists.

The ancient Greeks were great thinkers, and they often based their scientific explanations on reasoning rather than evidence. Indeed, some famous Greek philosophers rejected the need for scientif experiments. They believed that if enough clever men thought for long enough, they would discover the truth. This belief led to some incorrect theories. A **theory** is a proposed explanation for a set of facts.

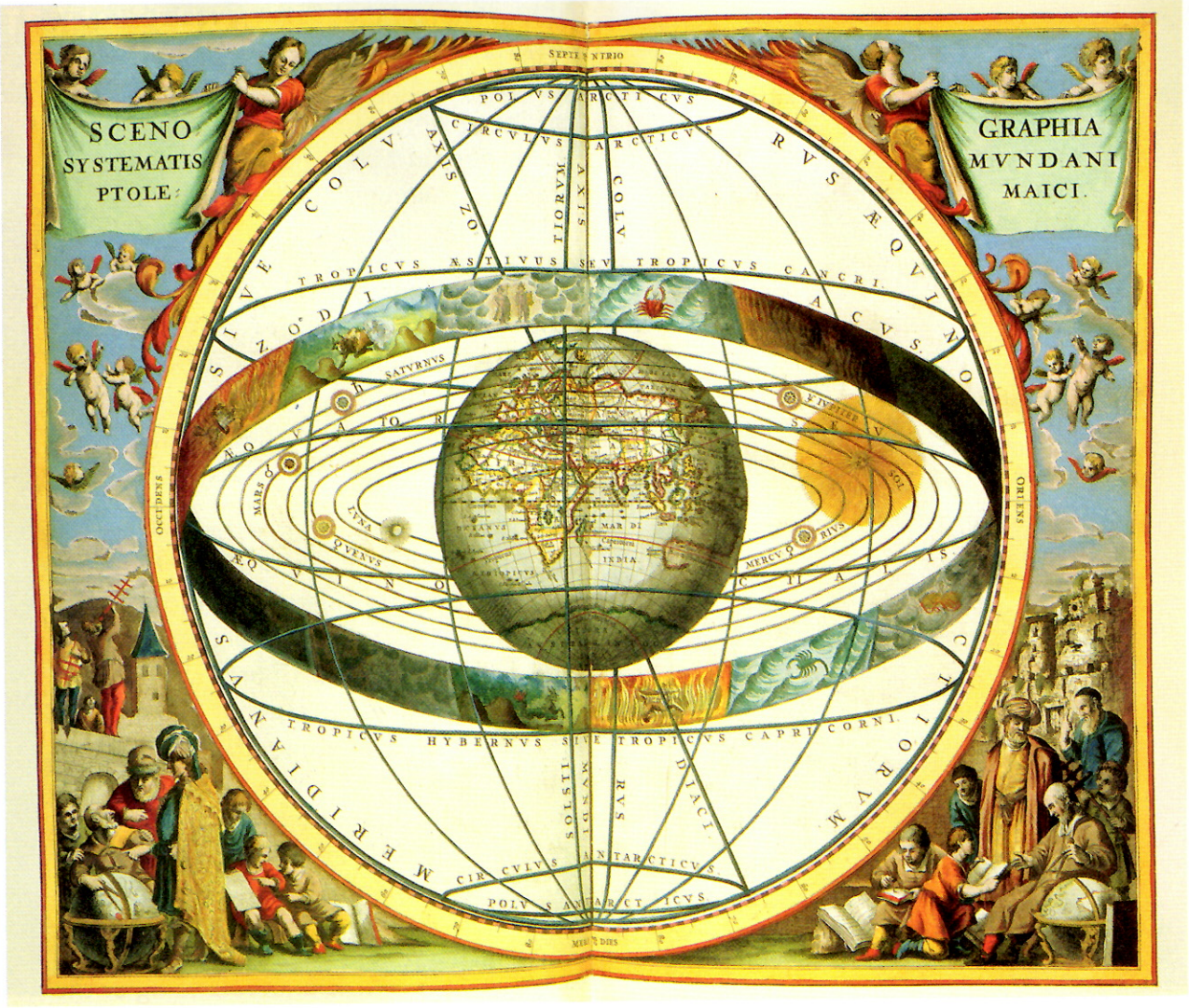
Two ancient Greek thinkers, Aristotle and Ptolemy, promoted the **geocentric theory**, which placed Earth at the center of the universe. According to this theory, the sun, moon, and planets all moved in a circular path around Earth. This theory later supported the Christian belief that God had created Earth at the center of the universe. Even though the theory was wrong, it influenced scientific ideas about the universe for hundreds of years.

In other areas, however, the ancient Greeks made some valuable contributions to scientific knowledge. For example, the Greek mathematicians Pythagoras, Euclid, and Archimedes (ahr-kuh-MEE-deez) developed theories on which modern mathematics is based.

MEDIEVAL MUSLIM SCHOLARS

After the collapse of the Roman Empire in A.D. 476, most classical knowledge was los to western Europe. However, it survived in the Muslim empire. Between the 600s and 1100s, Muslim scholars studied Greek scientific theories and combined them wit ideas from other regions. From India, for example, they adopted such mathematica concepts as the decimal system, the numb zero, and the ten Arabic numerals commo used today. By bringing together learning from different cultures, Muslim scholars advanced mathematical understanding.

Muslim scholars also made significant advances in astronomy. They developed special buildings called observatories for studying the stars. These buildings had scientific instruments that allowed astronomers to accurately plot the locations of stars. As a result, scientists



Scenographia Systematis Mundani (Harmonia Macrocosmica or Atlas Coelestis), 1660

were able to develop more accurate calendars and methods of navigation.

The advanced knowledge of the Muslims spread throughout their vast empire and beyond, eventually reaching western Europe after the 1200s. Beginning in the 1500s, European scientists combined this knowledge with new technology and a willingness to challenge long-accepted ideas. These actions sparked a revolution in scientific thinking.

GEOCENTRIC THEORY ^

This illustration from the 1600s depicts the geocentric theory, which incorrectly placed Earth at the center of the universe. The illustration shows the sun, moon, and other planets revolving around a much larger Earth. The surrounding band shows the signs of the zodiac, an imaginary belt in the heavens that encircles the orbits of the planets. The zodiac plays a major role in astrology, the study of how the stars and planets supposedly influence people's lives and events on Earth. In the Middle Ages, astronomy and astrology were closely linked.

REVIEW & ASSESS

1. **READING CHECK** What sources of knowledge did scholars turn to before the Scientific Revolution?
2. **DETERMINE WORD MEANINGS** How do the roots of the words *geocentric* and *observatory* help clarify their meanings?
3. **ANALYZE CAUSE AND EFFECT** How did medieval Muslim scholars help advance the field of mathematics?

7.10.1 Discuss the roots of the Scientific Revolution (e.g., Greek rationalism; Jewish, Christian, and Muslim science; Renaissance humanism; new knowledge from global exploration).

1.2 Discoveries and Inventions

You are a scientist living in the early 1600s. You spend many hours looking through a telescope, studying the stars and planets. Your observations lead you to believe the planets revolve around the sun. But you are afraid to publicly state this view because it conflicts with the teachings of the powerful Catholic Church. There could be serious consequences if you publish your findings.

MAIN IDEA

Improved technology and a focus on direct observation led to important scientific discoveries from the 1500s through the 1600s.

STRUCTURE OF THE UNIVERSE

The geocentric theory placed Earth at the center of the universe. According to this theory, the sun, planets, and stars revolved around Earth in perfect circles. Some scientists began to doubt this theory, however.

In the early 1500s, a Polish scientist named **Nicolaus Copernicus** was studying the locations of the stars to create a more accurate calendar. He noticed that his mathematical calculations worked better if he assumed that Earth revolved around the sun. He proposed the **heliocentric theory**, stating that the sun was the center of the universe. Copernicus published his theory in 1543, the year he died. His theory challenged the long-held view of Earth as the center of the universe.

The research of other scientists supported the heliocentric theory. The German scientist Johannes Kepler concluded that Copernicus's basic ideas were correct. Kepler added that the planets had **elliptical**, or oval, orbits rather than perfect circular ones.

Using more powerful telescopes, the Italian scientist **Galileo Galilei** (gal-uh-LAY-oh gal-uh-LAY-ee) made observations that further supported Copernicus's theory. In 1633, the Catholic Church condemned Galileo's discoveries and put him on trial. The church required Galileo to deny support for Copernicus's theory and kept Galileo under house arrest for the rest of his life. Over time, however, the heliocentric theory gained acceptance.

The English scientist **Isaac Newton** further expanded scientific understanding of the universe in the 1600s. He proposed the law of universal gravitation, which holds that all objects in the universe attract one another. With this law and his three laws of motion, Newton created a complete mechanical explanation of motion in the universe. The Royal Society of London, an organization dedicated to advancing and sharing scientific knowledge, helped spread Newton's ideas. His work would provide the foundation of modern physics and lead to scientific advances ranging from steam engines to space rockets.

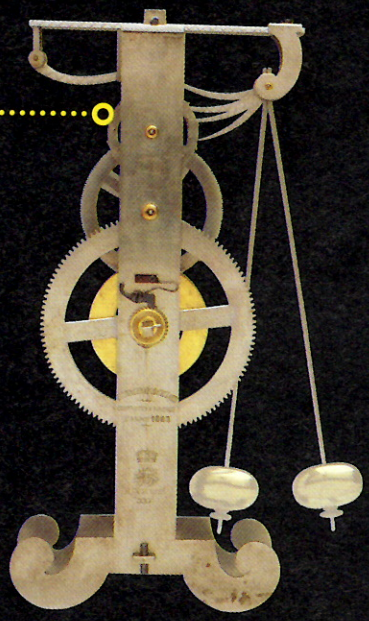
BIOLOGY AND CHEMISTRY

While some scientists explored the universe, others focused on life on Earth. The invention of the microscope around 1590 allowed biologists to explore a new microscopic world and to observe things that had previously been invisible to them.

TECHNOLOGY OF THE 1600s

Scientists developed new tools and instruments as the Scientific Revolution spread in the 1600s.

Galileo's Pendulum Clock
Galileo Galilei designed a clock operated by a pendulum. This model of Galileo's design was built in the 1800s.



Newton's Color Wheel
Isaac Newton experimented with light and invented the first color wheel.

Hooke's Microscope
Robert Hooke was among the first to build a practical compound microscope, which had more than one lens.

The English scientist **Robert Hooke** used his microscope to produce detailed drawings of tiny creatures, such as fleas. In 1665, Hooke coined the word *cell* to name the microscopic structures he observed in thin slices of cork. Hooke was the first scientist to describe cells.

Hooke worked closely with Irish scientist Robert Boyle. Together, they discovered that air is made up of gases and determined how changes in the volume of a gas affect the gas's pressure. They formed Boyle's Law to describe this relationship. Boyle's work with gases led him to propose that all matter is made up of smaller particles that join together in different ways. Boyle's theory challenged the ideas of Aristotle, who stated that the physical world consisted of the four elements of earth, fire, air, and water. The experimental work and writings of Hooke and Boyle greatly advanced the fields of biology and chemistry.

REVIEW & ASSESS

1. **READING CHECK** How did technology and direct observation help advance science in the 1500s and 1600s?
2. **MAKE INFERENCES** Why did the Catholic Church condemn Galileo's ideas?
3. **DRAW CONCLUSIONS** How did Robert Hooke advance the field of biology?

7.10.2 Understand the significance of the new scientific theories (e.g., those of Copernicus, Galileo, Kepler, Newton) and the significance of new inventions (e.g., the telescope, microscope, thermometer, barometer).

1.3 The Scientific Method

For more than 2,000 years, European scientists believed that a person's health depended on a balance of four body fluids called *humors*. They thought diseases were caused by an imbalance in these fluids. Even though no evidence supported the theory, European scientists did not question it.

MAIN IDEA

Two European philosophers, Sir Francis Bacon and René Descartes, helped advance a new approach to science in the 1600s.

SIR FRANCIS BACON

How do scientists develop knowledge? Most people would answer that scientists make observations and conduct experiments. But, surprisingly, that approach is relatively new. Before the 1600s, European scholars mainly referred to ancient Greek or Roman writers or to the Bible to decide what to believe. They did not seek answers by carefully observing nature themselves. The Scientific Revolution changed that approach. Scholars began to rely on observations, experiments, evidence, and reasoning in order to understand the natural world.

Galileo was one of the first scientists to actually test scientific ideas through experiments. Along with Copernicus and Kepler, he started a revolution in scientific thinking.

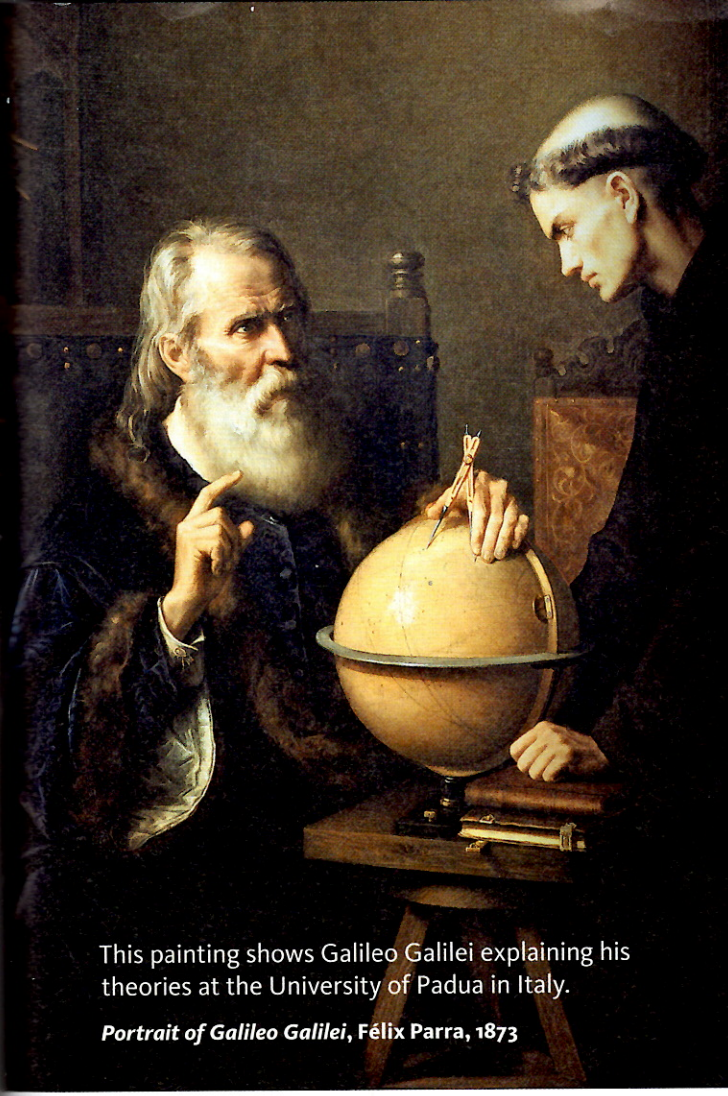
Two important thinkers of the 1600s—**Sir Francis Bacon** and **René Descartes** (reh-NAY day-KAHRT)—promoted ideas that eventually led to an entirely new approach to science. This approach, called the **scientific method**, is a logical procedure for developing and testing ideas. One of the key steps in the procedure is forming a **hypothesis**, an explanation that can be tested.

Sir Francis Bacon was an English philosopher, politician, and writer who had a strong interest in science. He pioneered a different approach to science in 1620 in the book *New Instrument*. Bacon urged scientists to gather data by following specific steps. Bacon's insistence on observation and experimentation as the keys to scientific accuracy became the cornerstone of modern science.

RENÉ DESCARTES

René Descartes was a brilliant French philosopher who shared Bacon's interest in science. But instead of emphasizing experimentation, Descartes relied on logic and mathematics to learn about the world. He agreed with Bacon on the need for proof in answering questions. In fact, Descartes believed that everything should be doubted until it was proved by reason.

Descartes went so far as to declare that the only thing he knew for certain was that he existed. He reasoned, "I think, therefore I am." From this starting point, Descartes used mathematical reasoning and logic to establish other certainties. Descartes argued that in mathematics, the answers were always correct because you began with simple, provable principles and then used logic to gradually build on them.



This painting shows Galileo Galilei explaining his theories at the University of Padua in Italy.

***Portrait of Galileo Galilei*, Félix Parra, 1873**

THE SCIENTIFIC METHOD

The scientific method is a logical approach for forming and testing ideas. The steps shown here describe the general approach. However, not all scientific inquiries follow the steps in this exact order.

Step One: Observe and Question

A scientist makes observations and gathers information on a subject. The scientist forms a question about the subject.

Step Two: Hypothesize

The scientist proposes a hypothesis, an idea or explanation that answers the question.

Step Three: Experiment

The scientist designs and conducts an experiment to test the hypothesis.

Step Four: Analyze Data

The scientist records and carefully examines the data from the experiment.

Step Five: Evaluate and Share Results

The scientist judges whether the data do or do not support the hypothesis and publishes an article describing the experiment and results.

The ideas of Bacon and Descartes became known as **scientific rationalism**. In this school of thought, observation, experimentation, and mathematical reasoning replaced ancient wisdom and church teachings as the source of scientific knowledge. Scientific rationalism provided a procedure for establishing proof for scientific theories. It laid a foundation for formulating theories on which other scientists could build.

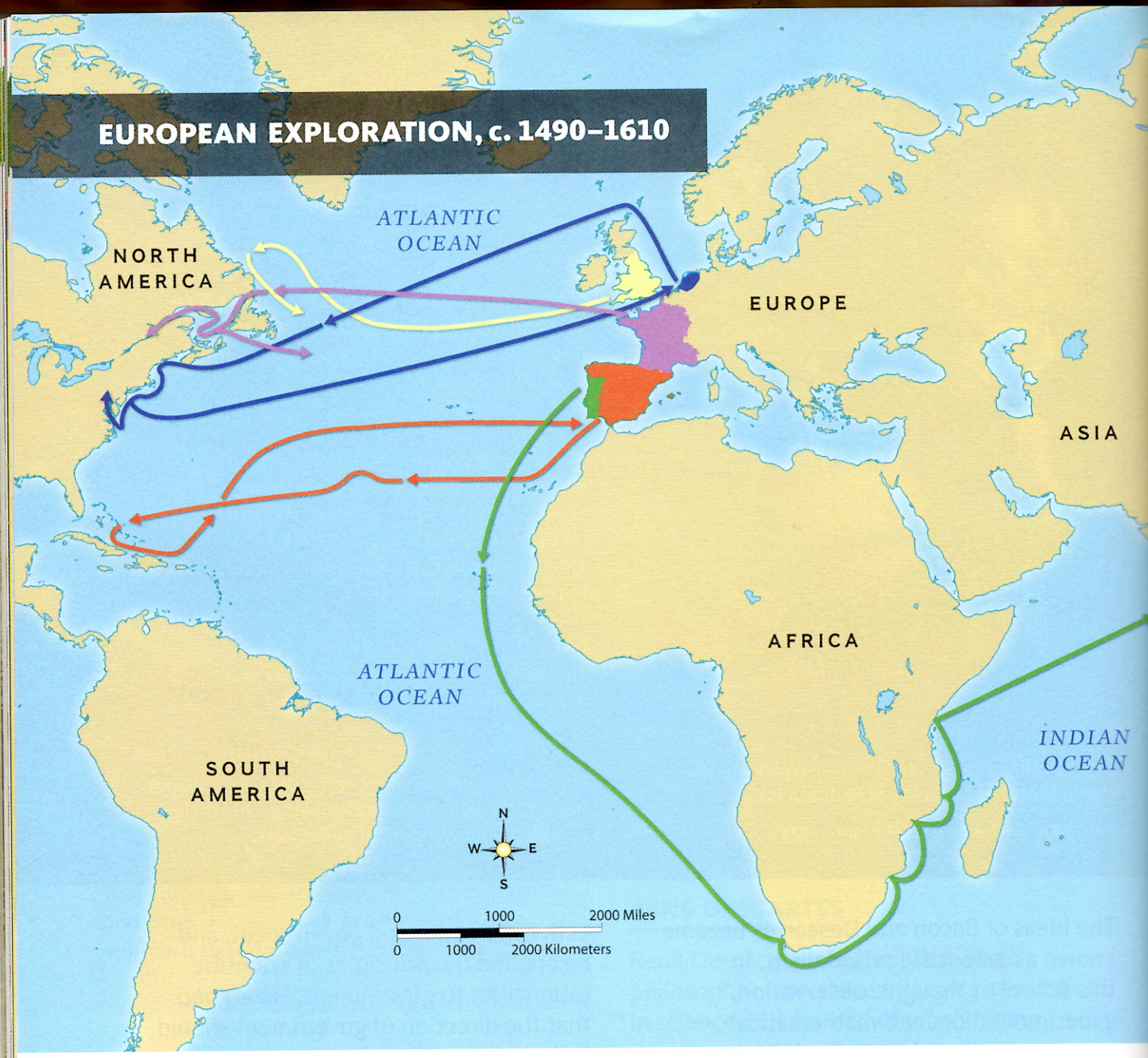
The influence of scientific rationalism extended beyond science. Bacon was active in politics and government, and he applied the principles of scientific rationalism to government. He argued that the direction of government should be based on actual experience.

Other writers argued that scientific rationalism encouraged people to think for themselves, so people should be allowed to take more control of their own lives. This thinking undermined the authority of the Catholic Church and contributed to the development of democratic government.

REVIEW & ASSESS

1. **READING CHECK** According to Bacon and Descartes, what are the best ways to build knowledge?
2. **EVALUATE** Why is it important to share the results of experiments?
3. **MAKE CONNECTIONS** How has the development of the scientific method affected your life?

7.10.3 Understand the scientific method advanced by Bacon and Descartes, the influence of new scientific rationalism on the growth of democratic ideas, and the coexistence of science with traditional religious beliefs; HI 3 Students explain the sources of historical continuity and how the combination of ideas and events explains the emergence of new patterns.



The map above shows a few of the many voyages of exploration that European countries sponsored between the 1400s and 1700s. The chart below describes the voyages shown on the map.

Sponsoring Country	Voyage
Spain →	**1492** Italian navigator Christopher Columbus lands in the Americas while searching for a western sea route to Asia.
Portugal →	**1497–1498** Portuguese explorer Vasco da Gama sails to India, establishing a direct sea route to Asia.
England →	**1497** Italian explorer John Cabot tries to find a northwest passage through North America to Asia. He paves the way for England's colonization of North America.
France →	**1535** French navigator Jacques Cartier explores the St. Lawrence River, in what is now Canada, hoping it will lead to Asia.
Netherlands →	**1609** English explorer Henry Hudson sails to the New World and explores the river that will later be named after him.