Scientific Revolution

“The Astronomer Copernicus: Conversation with God”
Jan Matejko (1872)

AP European History

J.F. Walters & G.W. Whitton
1. What contributions were made by scientists in the period from roughly 1540 to 1800?

2. How did the new discoveries in astronomy change the way people viewed the universe?

3. How did Bacon and Descartes influence thought in the Scientific Revolution?

4. What role did women play in the Scientific Revolution?

5. Why and how did governments in England and France become interested in science?
Journal 27-28/A: The seventeenth century has been called the century of genius.

—Palmer Chapter 27-28/A • pp. 225-40—

Directions: Using sentences or detailed bulleted notes, identify & explain the evidence Palmer uses to support the thesis listed above.
“The seventeenth century has been called the century of genius. One reason is that it was the age when science became ‘modern.’ It was the great age of Galileo and Sir Isaac Newton, whose combined lifetimes spanned the century with Galileo dying and Newton being born in the same year, 1642. When Galileo was young, those who probed into the secrets of nature still labored largely in the dark, isolated from one another and from the general public, working oftentimes by methods of trial and error, not altogether clear on what they were trying to do, with their thinking still complicated by ideas not nowadays considered scientific. They had nevertheless accomplished a good deal, without which the intellectual revolution of the seventeenth century would not have occurred. But in a way all scientific investigators before Galileo seem to be precursors, patient workers destined never to enter into the world toward which they labored. In 1727, when Newton died, all was changed. Scientists were in continual touch with one another, and science was recognized as one of the principle enterprises of European society. Scientific methods of inquiry had been defined. The store of factual knowledge had become very large. The first modern scientific synthesis, or coherent theory of the physical universe, had been presented by Newton. Scientific knowledge was applied increasingly to navigation, mining, agriculture, and many branches of manufacture. Science and invention were joining hands. Science was being accepted as the main force in the advancement of civilization and progress. And science was becoming popularized; many people who were not themselves scientists ‘believed’ in science and attempted to apply scientific habits of thought to diverse problems of social and political life.”

Scientific Revolution Basics

• Grew out of the spirit of the Renaissance
• Scientific Revolution part of the Age of Reason (along with The Enlightenment)
• Scientific Revolution’s core values
  ✓ world was rational, orderly, simple and predictable: natural law
  ✓ embraced empiricism: humans and their environment need to be studied
    ➡ promoted observation & experimentation
    ➡ valued measurement, precision & data collection
  ✓ developed “Scientific Method”
  ✓ knowledge = progress & power for humans
Astronomy
Nicolaus Copernicus

• Background & influences
  ✓ Polish monk & astronomer
  ✓ Ideas challenged Ptolemy’s geocentric model of the universe

• *On the Revolution of the Heavenly Orbs* (1543)
  ✓ Published on his death bed
  ✓ Developed heliocentric model of the universe
  ✓ Argued planets move in perfect circles around the Sun
  ✓ Earth rotates on its axis
  ✓ Findings based on mathematical calculations and naked-eye observations

Nicolaus Copernicus
1473-1543
Nicolaus Copernicus
Tycho Brahe

• Background & influences

✓ Danish noble, astronomer, alchemist & astrologer

✓ Lost his nose in a duel; wore a copper prosthetic nose

✓ Established a research institute

• Ideas/contributions

✓ Offered evidence supporting some of Copernicus’ theory

✓ Based on naked-eye observations

✓ Planets orbit sun in perfect circles

✓ Assisted by Johannes Kepler
Johannes Kepler

- **Background & influences**
  - ✔ German astronomer & mathematician
  - ✔ Nearly blind
  - ✔ Served as Brahe’s assistant

- **Ideas/contributions**
  - ✔ Offered further mathematical evidence of Copernicus’ heliocentric theory
  - ✔ Formulated Kepler’s “Laws of Planetary Motion”: planets move in ellipses around sun

Johannes Kepler
1571-1630
Galileo Galilei

• Background & influences
  ✓ Italian astronomer & physicist
  ✓ Eventually brought before Italian Inquisition for his theories

• Ideas/contributions
  ✓ Experiments analyzed mathematically
  ✓ Used telescope to make astronomical observations
    ➡ mountains on moon
    ➡ spots on sun
    ➡ 4 moons of Jupiter

Galileo Galilei
1564-1642

AP European History • Scientific Revolution • J.F. Walters & G. W. Whitton
“With no special insight into the science of optics, Galileo, a deft instrument-maker, had made his device [the telescope] by trial and error. But if Galileo had been merely a practical man, the telescope would not have been such a troublemaker. Other nations would have shared the Venetian Senate’s enthusiasm for a new device that served commerce and warfare by making distant objects seem close. For some reason, however, Galileo would not leave it at that. Early in January 1610 he did what now seems most obvious—he turned his telescope toward the skies. Today this would require neither courage nor imagination, but in Galileo’s day it was quite otherwise. Who would dare use a toy to penetrate the majesty of the celestial spheres? To spy out the shape of God’s Heaven was superfluous, presumptuous, and might prove blasphemous. Galileo was no better than a theological Peeping Tom.”

Biology
Ambroise Paré

• Background & influences
  ✓ French physician
  ✓ Royal surgeon for three French kings

• Ideas/contributions
  ✓ Developed ointment for preventing infections
  ✓ Developed stitches for closing wounds
  ✓ Improved amputation techniques
Andreas Vesalius

1514-1564

• Background & influences
  ✓ Flemish anatomist
  ✓ Built on ancient Greek Galen’s anatomical studies (who had dissected apes)

• Ideas/contributions
  ✓ Dissected human cadavers, usually from executed criminals
  ✓ First accurate and detailed study of human anatomy
  ✓ Made intricate sketches and drawings of human body
“When Vesalius took up his professorship, he gave surgery and anatomy a new significance. For he no longer considered his primary duty to be the expounding of Galen’s texts. In conducting his required ‘anatomy’ (from Greek for ‘cutting up’) he departed from custom. Unlike the professors before him, Vesalius did not stay seated high in his professorial cathedra while a barber-surgeon with bloody hands pulled organs out of the cadaver. Instead, Vesalius himself handled the body and dissected the organs. To help his students, he prepared some new teaching aids in the form of four large anatomical charts, detailed enough to show the student the body structure when there was no cadaver at hand. Each part was labeled with its technical name. An accompanying glossary and index listed the names of the parts in Greek, Latin, Arabic, and Hebrew.”

William Harvey

• Background & influences
  ✓ English physician
  ✓ Regarded as father of modern medicine

• On the Movement of the Heart and Blood (1628)
  ✓ Described circulation of blood
  ✓ Heart serves as a pump for the body

William Harvey
1578-1657
Antonie van Leeuwenhoek

• Background & influences
  ✓ Dutch biologist
  ✓ Accomplished lens grinder

• Ideas/contributions
  ✓ Perfected single-lens microscope
  ✓ Conducted observations using microscope
    ➡ blood corpuscles
    ➡ spermatozoa
    ➡ bacteria

Antonie van Leeuwenhoek
1632-1723
Methodology
Journal 27/A: Bacon and Descartes helped to develop the scientific method and emphasized the use of science for practical purposes.

—Palmer Chapter 27/A • pp. 226-31—
Directions: Using sentences or detailed bulleted notes, identify & explain the evidence Palmer uses to support the thesis listed above.
Francis Bacon

• Background
  ✓ English lawyer & statesman
  ✓ Laid the foundation of scientific methodology

• Novum Organum (1620)
  ✓ Novum Organum = new instrument
  ✓ Stressed scientific experimentation & observation
  ✓ Advocated empiricism
  ✓ Promoted inductive method (particular to general)
  ✓ Classify findings
  ✓ Science to benefit humans

Francis Bacon
1561-1626
René Descartes

• Background
  ✓ French scholar: mathematician & philosopher
  ✓ Founder of modern mathematics

• Discourse on Method (1637)
  ✓ Systematic Doubt
  ✓ Seek truth & knowledge in everything
  ✓ World can be reduced to mathematics
  ✓ Promoted deductive method (general to particular)
  ✓ Cartesian Dualism: God created two kinds of reality
    ➡ Subjective “thinking substance” (mind, spirit)
    ➡ Objective “extended substance” (everything else)
  ✓ “Cogito ergo sum.” (I think therefore I am.)
René Descartes
Gottfried Leibnitz

• Background & influences
  ✓ German mathematician & philosopher
  ✓ Contemporary of Isaac Newton

• Ideas/contributions
  ✓ Co-invented calculus with Isaac Newton
  ✓ Made contributions in a wide variety of fields
    ➡ Mathematics
    ➡ Physics
    ➡ Geology
    ➡ Engineering
    ➡ Psychology
  ✓ Believed God created best world possible
Journal 28/A: The Newtonian system led to intellectual humility and intellectual self-confidence.

—Palmer Chapter 28/A • pp. 231-40—

Directions: Using sentences or detailed bulleted notes, identify & explain the evidence Palmer uses to support the thesis listed above.
Isaac Newton

• Background & influences
  ✓ English mathematician, physicist & astronomer
  ✓ Educated at Cambridge University

• Mathematical Principles of Natural Philosophy (1687) [or Principia]
  ✓ Discovered universal law of gravitation
  ✓ Planetary motion of all celestial bodies governed by same set of natural laws
  ✓ Proved Copernicus’ heliocentric theory
Newton in 1712

• Newton’s other ideas/contributions
  ✓ Co-invented calculus with Gottfried Leibnitz
  ✓ Formalized the Scientific Method
  ✓ Invented reflective telescope
  ✓ Made significant discoveries in optics
  ✓ Studied sound
  ✓ Theorized about the formation of stars
  ✓ God created a rational universe

➡ Newton was a Deist: God created the world but did not intervene in its development or affairs once it was created

➡ Position raised questions about the importance of man and the role of religion
“The power and the grandeur of Newton’s system consisted, of course, in its universality. He finally offered one common scheme for terrestrial and celestial dynamics. He had brought the heavenly bodies down to earth, and at the same time provided a new framework, and new limits, for man’s grasp on the heavenly bodies. The legend of Newton and the apple is not entirely without foundation. The grand ‘notion of gravitation’ came to him, Newton himself said, ‘as he sat in a contemplative mood’ and ‘was occasioned by the fall of an apple.’ He had the bold imagination to think of the apple not simply as falling on his head but as being attracted to the center of the earth. Newton noted that the moon was sixty times as far from the center of the earth as the apple was, and therefore, by the inverse-square law, should have an acceleration of free fall of $1/(60)^2 = 1/3600$ of the acceleration of the apple. By applying Kepler’s third law, then, he could test his theory. There were a number of practical difficulties in this way—including Newton’s incorrect value for the radius of the earth. But his simple insight had put him on the way to his System of the World. He unified all the physical phenomena on earth with those in the heavens by the generality of his laws, expressed mathematically. For all the motions of earthly and heavenly bodies could be seen, observed, and measured. The grand unifying force in Newton’s system, even before gravitation, was mathematics.”

Notable Other
Margaret Cavendish

• Background & influences
  ✓ English noble (Duchess of Newcastle)
  ✓ Poet, playwright, & natural philosopher
  ✓ As a child, tutored in reading, writing and music

• Ideas/contributions
  ✓ Published six books on science in an age when it was a male-dominated field
  ✓ Critical of many of the new scientific theories
  ✓ Visited the Royal Society of London (but was not allowed to be a member)
Propagation & Popularization of Science

- Gutenberg’s moveable type press (c. 1455)
Propagation & Popularization of Science

- Scientific journals
- Government-supported scientific academies
  ✓ Royal Society of London (English Royal Society), 1662
  ✓ French Royal Academy of Science, 1666
- The Enlightenment (c. 1688-1789)
  ✓ salons
  ✓ Diderot’s Encyclopedia
### Review: Impact of Scientific Revolution

How did the Scientific Revolution impact views of....?

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Adapted from Jim Kirkcaldy, Hingham High School, Hingham, MA
The scientific revolution of the seventeenth century had repercussions far beyond the realm of pure science.
Sources


• A History of Western Society, 5/e, John P. McKay, et. al. (Boston: Houghton Mifflin, 1995).


• The Discoverers: A History of Man’s Search to Know his World and Himself, Daniel J. Boorstin (New York: Random House, 1983).


• Wikipedia.com (en.wikipedia.com).