

Name _____ Date _____ Period _____ SCORE _____/100

CHAPTER 16

The Scientific Revolution and the Emergence of Modern Science

Please staple the following items, IN THIS ORDER, behind this cover sheet:


1. * Lecture Notes
2. * Chapter Vocabulary
3. * Chapter Questions
4. * Chapter Review Packet

* = MANDATORY

-
5. Other Assignments = OPTIONAL - (essay questions, graded maps, charts, graphs, etc.)

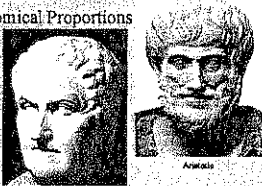
Chapter 16
.....
Toward a New Heaven and a New Earth:
The Scientific Revolution and the
Emergence of Modern Science
.....

Timeline



Background to the Scientific Revolution



- ☒ Medieval Science
- ☒ Renaissance Humanists
 - Contradictions of Aristotle and Galen
- ☒ Renaissance artists and their impact on scientific study
 - Close Observation of Nature
 - Perspective and Anatomical Proportions
- ☒ Technical Problems
- ☒ Mathematics
- ☒ Hermetic Magic
 - Alchemy



Galen Aristotle



Toward a New Heaven: A Revolution in Astronomy

- ✦ Aristotle, Claudius Ptolemy and Christian Theology
- ✦ Geocentric Universe
 - ◆ Ten Spheres surrounded the Earth
 - ◆ Christianized Ptolemaic Universe
- ✦ Copernicus
 - ◆ Nicolaus Copernicus (1473 – 1543)
 - ◆ On The Revolution of the Heavenly Spheres
 - ◆ Heliocentric Universe
 - ◆ Creates doubt about the Ptolemaic system

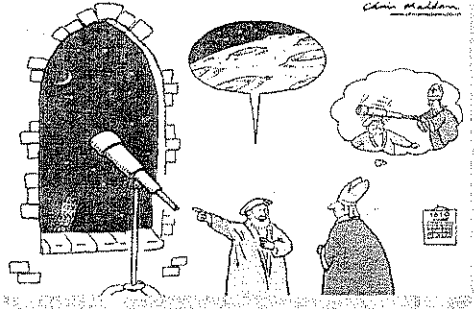


A Revolution in Astronomy, Continued

- ✦ Johannes Kepler (1571 – 1630)
 - ◆ Interest in Hermetic thought and Mathematical magic
 - ◆ "Music of the Spheres"
 - ◆ Laws of Planetary Motion
 - ◆ Discredits Ptolemaic System
- ✦ Galileo Galilei (1564 – 1642)
 - ◆ The Telescope
 - ◆ The Starry Messenger
 - ◆ Condemned by the Church
 - ◆ Scientific leadership passes to England, France and the Netherlands



Galileo explains his discoveries to the Pope.



Isaac Newton (1642 – 1727)

- ▣ Chair of Mathematics at Cambridge University
- ▣ Mathematical Principles of Natural Philosophy (1684 – 1686); The Principia
 - ◆ Three Laws of Motions
- ▣ Gravity
- ▣ World seen in mechanistic terms
- ▣ God



Advances in Medicine

- ▣ Medieval Medicine dominated by Galen
- ▣ Andreas Vesalius (1514 – 1564)
 - ◆ On the Fabric of the Human Body "Fabrica" (1543)
 - ◆ Dissection of a human body
 - ◆ Corrects Galen's errors
- ▣ William Harvey
 - ◆ On the Motion of the Heart & Blood (1628)
 - ◆ Circulation of the blood
- ▣ Paracelsus
 - ◆ Chemicals

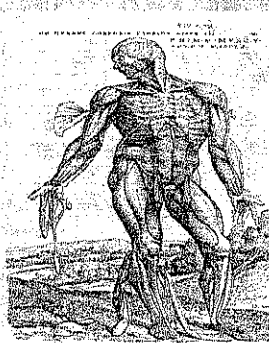


William Harvey



Paracelsus

Vesalius' Muscle Man from "Fabrica"



Women in the Origins of Modern Science

- ❖ New Opportunities for Women
- ❖ Largely informal education
- ❖ Margaret Cavendish (1623 – 1673)
 - ◆ Observations upon Experimental Philosophy
 - ◆ Grounds of Natural Philosophy
 - ◆ Attacked rationalist and empiricist approaches to scientific knowledge
- ❖ German Women
 - ◆ 1 of 7 German astronomers was a woman
 - ◆ Maria Winkelmann (1670 – 1720)
 - ◆ Discovered comet
 - ◆ Rejected for a post by the Berlin Academy

Orestes Kinn (Maria's husband)



Margaret Cavendish



Orestes Kinn (Maria's husband)

Debate over the nature and value of women

- ❖ Women portrayed as inherently base, prone to vice, easily swayed, and "sexually insatiable"
- ❖ Women joined debate in the 17th century and reject this view
- ❖ Science used to "perpetrate old stereotypes about women"
- ❖ Scientific revolution reaffirmed traditional ideas about women's nature





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

- ❖ Rene Descartes (1596 – 1650)
 - ◆ Discourse on Method (1637)
 - ◆ "I think, therefore I am."
 - ◆ Separation of mind and matter
 - ◆ Cartesian Dualism
 - ◆ Father of modern rationalism



The Spread of Scientific Knowledge


- ❖ The Scientific Method
 - ◆ Francis Bacon (1561 – 1626)
 - Rejects Copernicus and Kepler, Misunderstands Galileo
 - The Great Instauration (The Great Restoration)
 - Correct Scientific Method built on inductive principles
 - Proceed from the particular to the general
 - Experimentation
 - Control and domination of nature

Francis Bacon
 - ◆ Descartes
 - Deduction and mathematical logic

René Descartes
 - ◆ Newton
 - Unites Bacon's empiricism and Descartes rationalism


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)
- ❖ Societies recognized practical value of scientific research
- ❖ Both focus on theoretical work in mechanics and astronomy





Science and Society

- ❖ People recognized Science's rational superiority
- ❖ Science offered new ways to exploit resources for profit



Science and Religion in the Seventeenth Century

- Conflict between Science and Religion
 - Scientific beliefs triumph
 - Religious beliefs suffer
- Blaise Pascal (1623 - 1662)
 - Sought to keep science & religion united
 - Mystical vision (1654)
 - Pensées (Thoughts)
 - Sought to convert rationalists to Christianity
 - Christianity not contrary to reason
 - Reason had limits

IN THE SCIENTIFIC METHOD WHERE ARE THE FACTS? WHAT CONCLUSIONS CAN WE DRAW FROM THEM?	IN THE ORATORICAL METHOD WHERE IS THE CONCLUSION? WHAT FACTS CAN WE FIND TO SUPPORT IT?
	

Utilize the chapter readings, the textbook glossary, index, a dictionary, or any other helpful resource to help you identify, define, describe, or explain the following people, terms, words or phrases. When identifying people (1) include the dates of their life. e.g.: Charles VII (1422-1461) and (2) include a description of their importance (ideas, inventions, leadership/political qualities, famous artistic works, etc.).

- Section 1 pg. 448 (Background to the Scientific Revolution)
- Section 2 pg. 451 (Toward a New Heaven: A Revolution in Astronomy)
- Section 3 pg. 459 (Advances in Medicine and Chemistry)
- Section 4 pg. 461 (Women in the Origins of Modern Science)
- Section 5 pg. 463 (Toward a New Earth: Descartes, Rationalism, and a New View of Humankind)
- Section 6 pg. 465 (The Scientific Method and the Spread of Scientific Knowledge)

Section 1

1. Scientific Revolution
2. Alchemy and Hermetic Magic

Section 2

3. Geocentric Universe
4. Ptolëmy
5. Aristotle
6. Empyrean Heaven
7. Nicolaus Copernicus
8. *On the Revolutions of the Heavenly Spheres*
9. Heliocentric Universe
10. Tycho Brahe
11. Johannes Kepler
12. Three Laws of Planetary Motion
13. Galileo Galilei
14. *The Starry Messenger*

15. *Dialogue on the Two Chief World Systems*

16. Isaac Newton

17. *Principia*

Section 3

18. Galen

19. Four Bodily Humors

20. Paracelsus

21. Andreas Vesalius

22. *On the Fabric of the Human Body*

23. *On the Motion of the Heart and Blood*

24. Robert Boyle

Section 4

25. Margaret Cavendish

26. Maria Sibylla Merian

27. Maria Winkelmann

28. *Querelles des Femmes*

Section 5

29. Rene Descartes

30. *Discourse on Method*

31. Cartesian Dualism

32. Rationalism

Section 6

33. Scientific Method

34. Francis Bacon

35. *The Great Instauration*

36. Empiricism

37. English Royal Society

38. French Royal Academy of Sciences

39. *Journal des Savants*

40. *Philosophical Transactions*

41. Benedict de Spinoza

42. Blaise Pascal

43. *Pensees*

Utilize the chapter readings and thoroughly answer the following questions. Although complete sentences are not necessary, thoughtful, intelligent, thorough answers are required.

- Section 1 pg. 448 (Background to the Scientific Revolution)
- Section 2 pg. 451 (Toward a New Heaven: A Revolution in Astronomy)
- Section 3 pg. 459 (Advances in Medicine and Chemistry)
- Section 4 pg. 461 (Women in the Origins of Modern Science)
- Section 5 pg. 463 (Toward a New Earth: Descartes, Rationalism, and a New View of Humankind)
- Section 6 pg. 465 (The Scientific Method and the Spread of Scientific Knowledge)

Section 1

1. What developments during the Middle Ages and the Renaissance contributed to the Scientific Revolution?

Section 2

2. What did Copernicus, Kepler, Galileo, and Newton contribute to a new vision of the universe? Be specific and give examples.

Name	Contribution

3. PRIMARY SOURCE DOCUMENT QUESTION – “On The Revolutions of the Heavenly Spheres” (pg. 452)
(1) What major new ideas did Copernicus discuss in this selection? (2) What was the source of these ideas? (3) Why might one say that European astronomers finally destroyed the Middle Ages? (4) Why were the ideas of Copernicus so controversial?

- 1.
- 2.
- 3.
- 4.

4. PRIMARY SOURCE DOCUMENT QUESTION- "The Starry Messenger" (pg. 456)

(1) What was the significance of Galileo's invention? (2) What impressions did he receive of the moon? (3) Why were his visual discoveries so stunning and how did he go about publicizing them? (4) Why would these irrefutable discoveries have been so controversial and so threatening to clergymen of all faiths?

- 1.
- 2.
- 3.
- 4.

5. PRIMARY SOURCE DOCUMENT QUESTION- "Newton's Rules of Reasoning" (pg. 458)

(1) What are Newton's rules of reasoning? (2) Do they appear "modern"? If so, how? (3) How important were they to the development of the Scientific Revolution? (4) How would following these rules change a person's view of the world, of European religious traditions, and of ancient "science"?

- 1.
- 2.
- 3.
- 4.

Section 3

6. What did Paracelsus, Veslius, and Harvey contribute to a scientific view of medicine? Be specific and give examples.

Name	Contribution

Section 4

7. How did women come to play such an important role in the Scientific Revolution? How did male scientists view women and female scientists?

8. PRIMARY SOURCE DOCUMENT QUESTION – “The “Natural” Inferiority of Women” (pg. 463)
(1) What arguments does Spinoza use to support the idea of female inferiority? (2) What was the basis of his claims and assumptions? (3) How would you refute these arguments? (4) What was the effect of his line of reasoning upon the roles women could play?

1.

2.

3.

4.

Section 5

9. What was rationalism? Why was Descartes considered the founder of “modern rationalism”?

Section 6

10. How were the ideas of the Scientific Revolution spread, and what impact did they have on society and religion?

11. Why were seventeenth-century European intellectuals so intent on developing methods of study for entire bodies and specific fields of human knowledge? What did it mean then to become a methodical (or systematic) thinker or researcher?

CHAPTER SIXTEEN
TOWARD A NEW HEAVEN AND A NEW EARTH:
THE SCIENTIFIC REVOLUTION AND THE
EMERGENCE OF MODERN SCIENCE

Name:
Period:
Date:
Graded by:

Score: _____/50

Chapter Outline

- I. Background to the Scientific Revolution
 - A. Medieval Reliance on Classical Authority
 - B. Renaissance Scholars and the Discovery of Classical Disagreements
 - C. Artists and Close Observation of Nature
 - D. Early Modern Technological Innovations
 - E. New Mathematics
 - F. Hermetic Magic

- II. Toward a New heaven: A Revolution in Astronomy
 - A. Ptolemy's Model: A Geocentric Universe
 - B. Copernicus
 1. *On the Revolutions of the Heavenly Spheres*
 2. Heliocentric Model
 3. Church Reaction to Copernicus
 - C. Tycho Brahe and Johannes Kepler
 1. Observations
 2. "Music of the Spheres"
 3. Planetary Laws
 - D. Galileo and Controversy
 1. Galileo's Telescope
 2. *The Starry Messenger*
 3. Inquisition
 4. Laws of Motion
 - E. Isaac Newton and Universal Physics
 1. *Principia*
 2. Universal Law of Gravity

- III. Advances in Medicine
 - A. Influence of Galen
 1. Animal Dissection
 2. "Four Humors"
 - B. Paracelsus
 1. Medicine as Chemistry
 2. "Like Cures Like"
 - C. Andreas Vesalius
 1. Human Dissection
 2. Correction of Galen
 - D. William Harvey and the Human Blood System

- IV. Women in the Origins of Modern Science
 - A. Exclusion from Universities
 - B. Margaret Cavendish: Inspiration to Women
 - C. Maria Merian and Entomology
 - D. Maria Winkelmann
 - 1. Discovery of a Comet
 - 2. Rejection by the Berlin Academy
 - E. *Querelles des Femmes*
 - 1. Male Agreement about Female Inferiority
 - 2. Diminished Medical Role for Women

- V. Toward a New Earth: Descartes, Rationalism, and a New View of Humankind
 - A. Descartes' *Discourse on Method*
 - 1. Rejection of the Senses
 - 2. Separation of Mind and Matter
 - B. Implications of Cartesian Dualism

- VI. Scientific Method
 - A. Francis Bacon
 - 1. *Great Instauration*
 - 2. Inductive Method
 - 3. Practical Uses of Science
 - B. Rene Descartes' Emphasis on Deduction and Mathematics
 - C. Isaac Newton's Synthesis of Bacon and Descartes

- VII. Science and Religion in the Seventeenth Century
 - A. Example of Galileo
 - 1. Split Between Science and Religion
 - 2. Attempts at a New Synthesis
 - B. Benedict de Spinoza
 - 1. Panentheism
 - 2. Philosophy of Reason
 - C. Blaise Pascal
 - 1. *Pensées*: Apology for the Christian Faith
 - 2. Limits of Science and Reason

- VIII. Spread of Scientific Knowledge
 - A. Scientific Societies
 - 1. Royal Society of England
 - 2. Royal Academy of France
 - 3. Scientific Journals
 - B. Science and Society
 - 1. Acceptance through Practicality
 - 2. Science as a Means of Economic Progress and Social Stability

Chapter Summary

At the same time that kings were consolidating power and seeking a new social order based on absolute rule, an intellectual revolution took place which changed learned people's views of the universe, man's nature, and even the nature of truth itself. This revolution in science provided new models for heaven and for earth.

The Scientific Revolution began in the field of astronomy, and conclusions drawn by mathematicians and observers like Copernicus, Kepler, Galileo, and Newton both provided new understandings of the universe and its laws and called into question the wisdom of ancient and medieval scholars. Inspired by this study of astronomy and the realization that by empirical observation one can learn new things about the universe, scholars questioned and revised their opinions about medicine and the human sciences.

With the revolution in empirical studies came a new emphasis on human reason. Started by Rene Descartes and his famous *Discourse on Method*, the claims for rationalism focused attention on the nature and capacities of man's mind. While empiricism and rationalism were at times in conflict, they eventually merged to create a scholarship that rejected both tradition and authority in favor of continual reevaluation of established knowledge.

Religious doctrines were challenged and religious sensitivities ruffled by these secular endeavors, and scientists often found themselves at odds with religious powers. Even some of the scientists themselves were disturbed by the results of their studies. Pascal sought to reconcile science and religion, but his life was too brief to develop his ideas fully.

Yet science was too careful about its conclusions to be discredited and too useful to the world to be silenced. Scientific societies, sponsored by kings who saw benefits to their ambitions in science's achievements, disseminated amazing new discoveries and the general public enjoyed the fruits of scientific research. The modern world of progress and doubt was on its way.

Learning Objectives

1. Be able to trace the development of the science of astronomy from the work of Copernicus through that of Kepler, Galileo, and Newton.
2. Trace the development of the science of medicine from its early, primitive day through the discoveries of Paracelsus, Vesalius, and Harvey.
3. Explain the role that women played in the early years of modern science, recalling the obstacles that faced them.
4. Describe the competition between science and religion in the seventeenth century, and account for their inability to find common ground as Pascal longed to see.
5. Discuss the new scientific method of learning, the role of the scientific societies on its growth and influence, and the impact it had on European society.

Glossary of Names and Terms

1. Hermeticism: a belief that the world is a living embodiment of the divine and a magic-mathematical study the physical world can lead to God.
2. "Music of the Spheres": an early modern concept that creation, as demonstrated through its laws, has a harmony.
3. *Principia*: The work of Newton that captured and systematized all the laws of mechanics known to his day.
4. Paracelsus: early medical pioneer who believed that "like cures like" and gave drugs, often toxins, to his patients and kept records of his experiments.

5. Vesalius: medical pioneer who publicly dissected cadavers and published his findings in his book *On the Fabric of the Human Body*.
6. Margaret Cavendish: an aristocratic British woman scientist who, despite her recognized achievements, was excluded from the Royal Society on the basis of her gender.
7. *Querelles des femmes*: literally "arguments about women," from the debates held by male scientists over whether women should be accepted as academic and professional equals.
8. Francis Bacon: called for a total reconstruction of human knowledge, based now on scientific principles, which he gave concrete form.
9. Pascal: French mathematician who began but did not live to complete a work called *Pensées*, which he hoped would bridge the gap he saw growing between science and religion.
10. *Journal des Savants*: magazine of new scientific discoveries issued by the French Royal Academy of Sciences, which helped members keep up with each other's work.

Match the Following Words with their Definitions:

- | | |
|--------------------------------|---|
| 1. Nicholas Copernicus | A. Advocated a geometric universe and tried to discover the "music of the spheres" |
| 2. Tycho Brahe | B. Discovered the circulation of blood and showed it was caused by the pumping of the heart |
| 3. Johannes Kepler | C. Astronomer denied a post in the Berlin Academy |
| 4. <i>The Starry Messenger</i> | D. Made astronomical observations from an island given him by the King of Denmark |
| 5. Isaac Newton | E. Attempted to reconcile science and religion |
| 6. William Harvey | F. Louis IV's contribution to the French scientific revolution |
| 7. Maria Winkelmann | G. President of the Royal Society and only scientist buried in Westminster Abbey |
| 8. Rene Descartes | H. Regarded Ptolemy's geocentric universe as too complicated |
| 9. <i>Pensées</i> | I. Advocate of rationalism who began his method with doubt |
| 10. Royal Academy of Sciences | J. Defended Copernicus' system |

Choose the Correct Answer:

1. The Scientific Revolution of the seventeenth century was
 - a. stimulated by a new interest in Galen and Aristotle.
 - b. a direct result of the revolt against social conditions in the Middle Ages
 - c. born in the Augustinian monasteries.
 - d. more a gradual building on the accomplishments of previous centuries than a sudden shift in thought.
 - e. the cause of consternation among the kings of Europe.

2. The greatest achievements in science during the sixteenth and seventeenth centuries came in the areas of
 - a. astronomy, mechanics, and medicine.
 - b. astronomy, biology, and chemistry.
 - c. biology, mechanics, and ballistics.
 - d. engineering, physics, and dentistry.
 - e. anatomy, engineering, and medicine.

3. The general conception of the universe prior to Copernicus held that
 - a. heaven was at the center and all creation circled it.
 - b. the earth was at a stationary center, orbited by perfect crystalline spheres.
 - c. the earth rested on the shell of a giant turtle.
 - d. it was all a mystery known only to theologians.
 - e. to ask questions about it might threaten the Christian faith.

4. Although he made deductions about the construction of the universe, Copernicus was by formal training a
 - a. mathematician, specializing in Calculus.
 - b. banker attached to the Medici of Florence.
 - c. cloistered Augustinian monk.
 - d. military adviser to his uncle, an archbishop.
 - e. canon (church) lawyer.

5. The universal theories proposed by Copernicus
 - a. led to his arrest and imprisonment in a monastery.
 - b. were supported by Protestants in order to make Catholics look provincial.
 - c. made the universe less complicated by discarding Ptolemy's epicycle theory.
 - d. explained the appearance of the sun's rotation with a theory of earthly rotation.
 - e. were later completely discredited by Newton.

6. Johannes Kepler believed that the truth of the universe could be found by combining the study of mathematics with that of
 - a. Neoplatonic magic.
 - b. Greek literary symbolism.
 - c. the Book of Revelation.
 - d. the Book of Daniel.
 - e. papal dispensations.

7. Galileo held that the planets were
 - a. composed of material much like that of earth.
 - b. reflections of the divine city.
 - c. spheres composed of pure energy.
 - d. merely mirages in the "desert" of space.
 - e. inhabited by creatures made by a rival to God.

8. Isaac Newton's scientific discoveries
 - a. were met with great hostility from the Church of England.
 - b. formed the basis for universal physics until well into the twentieth century.
 - c. completely divorced God from the universe and its laws.
 - d. were the first to be printed in a language other than Latin.
 - e. alienated him both from the Royal Society and the English monarchy.

9. Newton's universal law of gravity
 - a. offered an explanation for all motion in the universe.
 - b. had little practical application to the questions of universal motion.
 - c. showed that humans could never understand why God made things the way they are.
 - d. seemed to indicate that the universe began with a "big bang."
 - e. was lifted almost word for word from Copernicus.

10. Paracelsus revolutionized the world of medicine in the sixteenth century by
 - a. disproving Galen's theory of two blood systems.
 - b. dissecting human rather than animal cadavers.
 - c. treating diseases with his "like cures like" method.
 - d. rejecting "Christian Chemistry" as taught in the universities of his day.
 - e. injecting himself with germs to note their effects.

11. The role of women in the Scientific Revolution was best characterized by
 - a. the way scientific communities welcomed women as members.
 - b. Maria Merian's breakthroughs in astronomy.
 - c. the manner in which Margaret Cavendish debated science with men.
 - d. Maria Winkelmann's professorship in physics at the University of Berlin.
 - e. Spinoza's arguments for the full equal treatment of women.

12. The overall effect of the Scientific Revolution on the *querelles des femmes* was to
- dispel old myths about female inferiority.
 - increase the role of husbands in child care and education.
 - justify the continuation of male dominance in the field.
 - demonstrate that there was no inherent skeletal differences between the sexes.
 - break down old walls and permit women their proper place in the field.
13. Maria Merian introduced to the field of science the importance of
- sterilizing surgical instruments.
 - viewing heavenly bodies through smoked lenses rather than with the naked eye.
 - reconciling scientific findings with theological principles.
 - not judging a person's work by his or her gender.
 - providing precise illustrations of her subjects.
14. Francis Bacon was important to the Scientific Revolution because of his emphasis on
- experimentation and inductive reasoning.
 - pure, theoretical reasoning.
 - deductive conclusions, which moved from general to particular principles.
 - the obligation of scientists to protect nature.
 - reconciling science with religion.
15. Organized religion in the seventeenth century
- conceded that only science can explain the universe.
 - rejected scientific discoveries that conflicted with Christian theology's view of the universe.
 - cooperated as an equal and willing partner to the study of science.
 - simply ignored science, calling it a new "toy for the minds of God's children."
 - tried to imprison every scientist who threatened the faith.
16. During the seventeenth century, royal and princely patronage of science
- declined as science turned more and more to medicine.
 - was strongest in Italy and Spain.
 - became an international phenomenon.
 - replaced church funding of scientific research.
 - put severe limits on the scope of scientific experimentation.
17. The scientific societies established the first
- fundraising events for medical research.
 - journals describing the discoveries of members.
 - codes of ethics for the treatment of animals.
 - codes of ethics for the treatment of humans.
 - endowed chairs of science in the universities.

18. Spinoza said that man's failure to understand the true nature of God leads to
- a false worship of nature.
 - a society in which men use nature for selfish purposes.
 - a decline in the powers of moral judgment.
 - sexual permissiveness.
 - slavish devotion, exemplified by monastic deprivation.
19. Blaise Pascal believed that
- man can know God through pure reason.
 - man is the summation of all things.
 - Christians should trust only what God has revealed in Scripture.
 - god can be known only by the heart, not the reason.
 - faith and reason would find resolution given enough time.
20. Science became an integral part of Western culture in the eighteenth century because
- people came to see it as the only way to find the truth.
 - its mechanistic theories were popular with kings.
 - radical groups like the Levellers, when they came to power, insisted on the adoption of scientific laws.
 - it offered a new means of making profit and maintaining social order.
 - there was no alternative to its good sense.

Complete the Following Sentences:

- Renaissance humanists demonstrated that not all ancient scholars had agreed with _____, _____, and _____, even though these men were accepted without question by medieval science.
- Early modern scientists agreed with Leonardo da Vinci that since God eternally _____, nature is inherently _____; yet these same scientists looked for the secrets of the universe through _____ magic.
- Copernicus rejected Ptolemy's _____ universe and postulated a _____ one because he found Ptolemy's system too _____.
- Peering through his telescope, Galileo discovered _____ on the moon, Jupiter's four _____, and _____ spots.
- Galileo explained the three approaches people might take to the new astronomy in his *Dialogue*, where three characters, _____, _____, and _____ argued the theory of Copernicus.
- During eighteen months in his home village, Isaac Newton invented _____, developed theories about the composition of _____, and began formulating the universal law of _____.

7. Vesalius disputed Galen's assertion that blood vessels originate in the _____ but did not doubt his claim that two different kinds of blood flow through the _____ and _____.
8. Descartes argued that man's _____ cannot be doubted but that the reality of the _____ can and should be, thus creating what came to be called Cartesian _____.
9. Although he was expelled from his Amsterdam _____ for heresy, Spinoza was actually a _____, not the atheist his critics claimed, believing that all things are in _____.
10. The Royal Society was chartered in 1662 by _____, while the Royal Academy of Sciences was recognized in 1666 by _____. Both emphasized the _____ value of scientific research.

Place the Following in the Order of their Publications and Give Dates

- | | |
|--|----|
| 1. Harvey's <i>On the Motion of the Heart and Blood</i> | 1. |
| 2. Newton's <i>Principia</i> | 2. |
| 3. Copernicus' <i>On the Revolutions of the Heavenly Spheres</i> | 3. |
| 4. Bacon's <i>The Great Instauration</i> | 4. |
| 5. Descartes' <i>Discourse on Method</i> | 5. |
| 6. Pascal's <i>Pensées</i> | 6. |
| 7. Galileo's <i>The Starry Messenger</i> | 7. |

Questions for Critical Thought

1. Discuss the causes of the Scientific Revolution of the seventeenth century. Of these causes, which seems strangest to modern minds? Why?
2. What did the discoveries in seventeenth century astronomy contribute to the Scientific Revolution? What did each of the major astronomers add to the field?
3. What three men added knowledge to the field of medicine during the seventeenth century? Briefly describe each one's contribution to the field.
4. Describe the contribution of women to the Scientific Revolution. Why did male scientists have such difficulties accepting them as equals?
5. Discuss the ways in which scientific discoveries affected the seventeenth century's image of man. How did the new image differ from the old one?

6. Describe the "scientific method" that developed in the seventeenth century, and show how it was used in one of the emerging branches of science.
7. How did the Scientific Revolution affect religious thought? How did religious thought affect the Revolution?
8. What role did monarchs play in the Scientific Revolution? What were their motivations, and to what extent were their expectations realized?

Analysis of Primary Source Documents

1. Using the *Life of Jerome Cardan* as your example, demonstrate the close relationship, as late as the sixteenth century, between science and what scientists today call superstition.
2. Show how Copernicus' heliocentric theory was at the same time so simple and so profound.
3. Describe the "tone" of the famous correspondence between Kepler and Galileo. How can you explain the apparent absence of jealousy usually associated with famous men?
4. What personality traits can you find in Galileo's account of his astronomical observations that would explain why he was a successful scientist?
5. Show how Isaac Newton's four rules of reasoning are the end result of two centuries in which the "scientific method" was developed and refined.
6. Speculate on why—amid the scientific progress of his century and despite evidence to the contrary—Spinoza was so unprepared to accept women as equals.
7. To what degree do you find Descartes' method for finding truth a good guide? Point out any difficulties one might meet applying it to contemporary scientific problems.
8. What was at the root of Pascal's doubts about man's ability to find scientific certainty? What problems for science in the future did he accurately predict?

CHAPTER 16

TOWARD A NEW HEAVEN AND A NEW EARTH: THE SCIENTIFIC REVOLUTION AND THE EMERGENCE OF MODERN SCIENCE

EXAMINATION QUESTIONS

Essays:

1. What were the roots of the Scientific Revolution? How do you explain its emergence?
2. How did seventeenth-century science differ from medieval science? Renaissance science? What was the old Ptolemaic conception of the universe and what did Copernicus, Kepler, and Galileo contribute to the development of the heliocentric theory of the cosmos? What was the reaction of the church to their findings?
3. What do we mean by the Newtonian world-machine? How did Newton arrive at this conception? What are the broader social, political, and cultural implications of viewing the entire universe as a machine?
4. What did Paracelsus, Vesalius, and Harvey contribute to a scientific view of medicine? Be specific and give examples.
5. How did women contribute to the beginnings of modern science? How did male scientists view women and female scientists?
6. What was rationalism? Why was Descartes considered the founder of "modern rationalism"?
7. Compare the methods used by Bacon and Descartes. Would Pascal agree with the methods and interests of these men? Why or why not?
8. How was the new scientific knowledge spread in the seventeenth century?
9. Why were seventeenth-century European intellectuals so intent on developing methods of study for entire bodies and specific fields of human knowledge? What did it mean then to become a methodical (or systematic) thinker or researcher?
10. What was "new" and what was not new about the seventeenth century's "New Heaven and a New Earth"? Be specific and give examples.

Identifications:

1. "God's handiwork"
2. "natural philosophers"
3. alchemy and hermetic magic
4. Ptolemaic universe
5. Aristotle
6. geocentric universe
7. the Empyrean Heaven
8. epicycles
9. Nicolaus Copernicus
10. *On the Revolutions of the Heavenly Spheres*
11. heliocentric universe
12. Tycho Brahe
13. Johannes Kepler

14. three laws of planetary motion
15. Galileo Galilei
16. *The Starry Messenger*
17. *Dialogue on the Two Chief World Systems*
18. the Inquisition
19. Isaac Newton
20. *Principia*
21. universal law of gravitation
22. Galen
23. four bodily humors
24. Paracelsus
25. "new drugs"
26. Andreas Vesalius
27. *On the Fabric of the Human Body*
28. William Harvey
29. *On the Motion of the Heart and Blood*
30. Robert Boyle
31. Antoine Lavoisier
32. Margaret Cavendish
33. Maria Sibylla Merian
34. Maria Winkelmann
35. *querelles des femmes*
36. Rene Descartes
37. *Discourse on Method*
38. "I think therefore I am"
39. Descartes' deductive method
40. Scientific Method
41. Francis Bacon's inductive method
42. "to conquer nature in action"
43. Benedict de Spinoza's pantheism
44. *Ethics Demonstrated in the Geometrical Manner*
45. Blaise Pascal
46. *Pensees*
47. English Royal Society
48. French Royal Academy of Sciences
49. *Journal des Savants*
50. *Philosophical Transactions*