I. Background to the Revolution

A. Medieval scientists, known as "natural philosophers," did not make observations of the world and nature so much as rely on ancient authorities, especially Aristotle, for their scientific knowledge. Changes in the 1400s and 1500s caused European scientists to adopt new views and methods.
B. Renaissance humanists studied the newly discovered works of **Ptolemy,** Archimedes, Plato, and other ancient thinkers. They learned that some ancient thinkers had disagreed with Aristotle and other accepted authorities.
C. Technical problems, like calculating how much weight a ship could hold, spurred a movement towards observation and measurement. New instruments like the telescope and microscope made fresh observations and discoveries possible. Printing spread ideas more quickly than ever before.
D. The study of mathematics in the Renaissance contributed to the important role mathematics had in the scientific achievements of the sixteenth and seventeenth centuries. The great scientists of the day believed that the secrets of nature were written in the language of mathematics.
E. These intellectuals—Copernicus, Kepler, Galileo, Newton, and others—developed new theories that became the foundation of the Scientific Revolution.

II. A Revolution in Astronomy

A. Born in the second-century A.D., Ptolemy was antiquity's greatest astronomer. Medieval philosophers constructed a **geocentric** (Earth is at the center) model of the universe called the **Ptolemaic system.** It is a series of concentric spheres with a motionless Earth in the middle.
B. According to Ptolemy, the planets are in different, crystal-like spheres. They rotate, which accounts for the movements of the heavenly bodies. The tenth sphere is the "prime mover," which moves itself and gives motion to the other spheres. Beyond this is Heaven, where God and all the saved souls reside.
C. Nicholas Copernicus of **Poland** published his famous work, *On the Revolutions of the Heavenly Spheres,* in 1543. He believed his **heliocentric** (with the Sun in the center) system was more accurate than the Ptolemaic system. Copernicus argued that all the planets revolved around the sun, the Moon revolved around Earth, and Earth rotated on its axis.
D. The German mathematician Johannes Kepler also helped destroy the Ptolemaic system. His observations confirmed that the Sun was at the center of the universe, and he tracked the elliptical orbits of the planets. Ptolemy had insisted that the orbits were circular.
E. The Italian scientist and mathematician **Galileo Galilei** answered one of the two remaining questions for the new astronomy: What are the planets made of? He was the first European to make regular observations with a telescope. He saw mountains on the Moon and the four moons orbiting Jupiter. Ptolemy had said the heavenly bodies were pure orbs of light, but now it appeared they were material.
F. Galileo's work began to make Europeans aware of the new view of the universe. He got into trouble with the Catholic Church, which ordered him to abandon the new system because the Copernican conception contradicted that of the Church and the Bible. In the Copernican system the heavens were not spiritual but material, and God was no longer in a specific place. Most astronomers believed the new conception, however.
G. The Englishman **Isaac Newton** responded to the second question for the new conception of the universe: what explains motion in the universe? He was a mathematics professor at the **University of Cambridge.**
H. Newton published his views in *Mathematical Principles of Natural Philosophy*, also known as the *Principia*. He defined the three laws of motion in the universe. Crucial to his view was the **universal law of gravitation:** every object in the universe is attracted to every other object by a force called gravity. This explained why planetary bodies did not go off in a straight line, but traveled in elliptical orbits.
I. Newton gave the world a picture of the universe as a huge, regulated, uniform machine. This picture dominated the modern worldview until Einstein's theory of relativity.

III. Breakthroughs in Medicine and Chemistry

A. In the Late Middle Ages, medicine was dominated by the teaching of the Greek physician Galen (second century A.D.) His views about anatomy were often wrong because he used animals, not people, for dissection.
B. The new anatomy of the sixteenth century was based on the work of Andreas Vesalius, published in his *On the Fabric of the Human Body* (1543). He reported his results from dissecting human bodies as a professor of surgery at the University of **Padua,** presenting an accurate view of the individual organs and general structure of the human body. He erroneously believed that the body had two kinds of blood.
C. William Harvey's *On the Motion of the Heart and Blood* (1628) showed that the heart, not the liver as Galen had thought, was the beginning point of the blood's circulation. He also showed that the same blood runs through veins and arteries and that the blood makes a complete circuit through the body. Harvey's work was based on close observation and experiment.
D. The work of **Robert Boyle** in chemistry was also based on close observation and experiment. He formulated Boyle's Law about gases—the volume of a gas varies with the pressure exerted on it. In the eighteenth century Antoine Lavoisier, the founder of modern chemistry, invented a system of naming the chemical elements.

IV. Women and the Origins of Modern Science

A. One of the most prominent female scientists of the seventeenth century was **Margaret Cavendish.** In works such as her *Observations Upon Experimental Philosophy*, she criticized the belief that humans, through science, were the masters of nature.
B. In Germany many women scientists were astronomers. They often received training in family observatories from their fathers or husbands. **Maria Winkelmann** was the most famous; she assisted her husband, the famous Prussian astronomer Gottfried Kirch, and discovered a comet.
C. Winkelmann was denied a post as assistant astronomer at the Berlin Academy because of her gender. In the view of most people of the seventeenth century, science and scholarship conflicted with the domestic roles women were expected to fulfill.

V. Descartes and Reason

A. The work of the French philosopher **René Descartes** strongly reflects the Western view of humankind that came from the Scientific Revolution. In his *Discourse on Method* (1637) he asserts that he can rationally be sure of only one thing—his own existence. He asserted he would accept only those things his reason said were true.
B. Descartes asserted that while he could not doubt the existence of his mind—"I think, therefore I am"—he could doubt the existence of the material world. He concluded that the material world and the mental world were two different realms. He separated mind and matter. This made matter something inert and independent of the observer that could be investigated by a detached rationality.
C. Descartes has been called the father of modern **rationalism.** This system of thought is based on the idea that reason is the chief source of knowledge.

VI. The Scientific Method

A. During the Scientific Revolution, people were concerned about how they could best understand the physical universe. They created the **scientific method.** The philosopher **Francis Bacon** was most responsible for this method.
B. Bacon emphasized arriving at conclusions about nature using **inductive reasoning,** or making generalizations from particular observations and experiments organized to test hypotheses.
C. He believed science was to give human kind new discoveries and the power to serve human purposes by conquering "nature in action." The control and domination of nature became an important concern of science and its accompanying technology.