

Lecture 5, Chapter 16:
Science and Life in the 16th and 17th Centuries

The re-introduction of Aristotelian philosophy began to impact science in this era. Aristotle's form of logic began to impact people's notions of experiments and conjectures, leading to the modern scientific method.

Astronomy

1. Ptolemy, 2nd century A.D.: proved the earth was round, but he:
 - a. misjudged the distance between Europe and Asia to the west; his underestimation led Columbus to think he could reach Asia by sailing west.
 - b. thought the earth stood still, with the sun, moon, planets, and stars revolving around the center of the earth. Problem: when people began keeping exact observations of planetary movements in the 15th century, Ptolemy's "spheres" didn't adequately explain the movements as observed.
2. Nicolas Copernicus (1473-1543)
 - a. Polish priest who was an amateur astronomer
 - b. began studying astronomy in university
 - c. 1514: developed his heliocentric hypothesis: the planets revolved around the sun
 - i. earth and the planets revolved around the sun
 - ii. proposed circular orbits for the planets
 - iii. proposed the earth rotates every 24 hours on its axis
 - d. 1543: publication of his book, *On the Revolutions of the Heavenly Spheres*. It is said that a finished copy was put in Copernicus' hands as he lay on his deathbed.
3. Tycho Brahe (1546-1601)
 - a. Danish
 - b. in college at age 20, became involved in a drunken duel with broadswords; Tycho lost the tip of his nose. He later replaced it with a metal tip. (an exhumation of his body in 1901 proved the metal tip was copper, not gold or silver as had been thought.)
 - c. his uncle, a Danish court official, wanted Tycho to study law; he studied astronomy instead.
 - d. realized that only systematic, continual observations of the planets and stars would advance the science of astronomy
 - e. using only his eyes, Tycho made accurate measurements of the planetary movements
 - f. 1572: Tycho recorded a "nova" ("new star") in the constellation Cassiopeia; disproved the Aristotelian view that the heavens never changed. Tycho's "new star" was actually a supernova.
 - g. Tycho's measurements of Mars were later instrumental in Kepler's discovery of the laws of planetary motion
 - h. interestingly, Tycho never believed in the Copernican view of the solar system; continued to believe the heavens rotated around the earth
4. Johannes Kepler (1571-1630)
 - a. German
 - b. Tycho Brahe's assistant
 - c. observed the comet of 1577 and a lunar eclipse in 1580 as a child; gave him a desire to study astronomy
 - d. 1599: became Tycho's assistant. Became Imperial Mathematician after Tycho's death
 - e. Believed Copernicus was right, but couldn't make sense of Copernican theory with circular planetary orbits

- f. Using Tycho's observations, Kepler formed his laws of planetary motion:
 - i. Every planet follows an oval-shaped path, or orbit, around the sun, called an ellipse. The sun is located at one focus of the elliptical orbit.
 - ii. An imaginary line from the center of the sun to the center of a planet sweeps out the same area in a given time. This means that planets move faster when they are closer to the sun.
 - iii. The time taken by a planet to make one complete trip around the sun is its period. The squares of the periods of two planets are proportional to the cubes of their mean distances from the sun.¹
 - g. 1604: observed a supernova as did Tycho in 1572; these 2 supernovae were the last observed in the Milky Way
5. Galileo Galilei (1564-1642)
- a. Italian, born in Pisa
 - b. rejected elliptical orbits but accepted that the planets rotated around the sun
 - c. used a telescope to view the moons of Jupiter and the phases of Venus, proving that not every heavenly body rotated around the earth
 - d. used a telescope to see craters and mountains on the moon
 - e. using rolling balls, proved that every object accelerates at the same rate, independent of mass
 - f. laid the foundation for Newton's later laws of motion
 - g. trouble with the Catholic Church
 - i. many Church astronomers agreed with Galileo regarding the heliocentric view
 - ii. Galileo's primary problem: he was arrogant toward his opponents
 - iii. 1613: Galileo published a letter stating that the Copernican theory was compatible with Catholic doctrine and Scripture. Opponents sent the letter to the Inquisition in Rome. Galileo was told not to "hold or defend" the Copernican theory; he could treat it as a theory only
 - iv. 1623: Galileo's friend, Maffeo Barberini, became Pope Urban VIII; gave Galileo permission to ignore the ban and write a book as long as it didn't openly support Copernicus
 - v. 1632: *Dialogue on the Two Chief World Systems: Ptolemaic and Copernican*
 - 1. published in Italian rather than Latin; insured widespread publication and debate
 - 2. 2 characters in the book, a simpleton supporting Ptolemy and an intellectual supporting Copernicus
 - 3. Problem: the pope was offended by Galileo's portrayal of the Ptolemaic system as ignorant
 - 4. 1633: Galileo was forced to recant his book before the Inquisition in Rome. He was sentenced to life imprisonment, but the sentence was commuted to house arrest. *Dialogue* was placed on a list of banned books, where it stayed until 1832.
 - vi. 1992: Pope John Paul II issued an apology for the Galileo affair
6. Isaac Newton (1642-1727)
- a. 1665-1667: invented calculus to explain his laws of gravity and motion
 - b. realized that all bodies in the universe are attracted to one another by gravity
 - c. 1687: *Principia Mathematica (Mathematical Principles of Natural Philosophy)*: explained laws of motion:

1. Source: *World Book Encyclopedia*, 2003 edition, v. 7.1.1.

- i. inertia (what's at rest or motion tends to remain that way until acted on by an external force)
- ii. rate of change in the motion of an object is proportionate to the force acting on it
- iii. to every action there is an equal and opposite reaction
- d. These laws explained the revolution of the planets around the sun; seemed to imply that the universe worked like a well-constructed clock
- e. optics: determined that white light has every possible color of light in it (led to the science of spectrum analysis, the determining of the composition of an object by the color of light it emits)
- f. constructed the first reflecting telescope

Biology

1. Prior to this time, all anatomical texts relied on the work of Galen, a Greek anatomist. Problem: Galen didn't dissect humans; he dissected animals and assumed human anatomy was the same
2. Andreas Vesalius (1514-1564): used human cadavers to write his book, *On the Structure of the Human Body* in 1543.
3. William Harvey (1578-1657): English physician who determined the method by which blood flows in the human body; determined that the heart acts like a pump
4. Anton van Leeuwenhoek (1632-1723): Dutch microscope maker who first observed bacteria, microscopic organisms, and striated human tissue under microscopes.

Impact of Christianity on science: Christianity — especially Calvinism — taught that God ordained laws by which the universe operated; to know these laws was to know God's will. God does not break His own laws, therefore these laws can be learned by observation and experimentation.

Literature

Elizabethan Age

1. Sonnets, plays
2. 1576: first playhouse, The Theatre, built in London
3. William Shakespeare (1564-1616)
 - a. born in Stratford-on-Avon
 - b. wrote 37 plays on all types of subjects
 - c. wrote at least 150 sonnets and other poetry
 - d. Play company: Lord Chamberlain's Men
 - e. Theater: the Globe; held 3,000 people
 - f. 1603: James I gave Shakespeare a royal license; the Lord Chamberlain's Men became the King's Men
4. John Donne
5. King James Bible
 - a. churches used the Bishop's Bible, laity used the Geneva Bible
 - b. James approved the translation from Greek and Hebrew texts; translation would be published without marginal notes
 - c. 47 men in 6 panels: 2 at Oxford, 2 at Cambridge, 2 at Westminster Abbey