Chapter VII. The Scientific View of the World
pp. 287 - 313

Introduction: "The Seventeenth Century has been called the century of genius." Between the birth of Galileo and the death of Newton, science became "modern." When Galileo was young, scientists were alone and the proper methodology was not clear; by the death of Newton (1727) scientists were a community, science had prestige, methods of inquiry had been defined, the store of knowledge had been vastly increased, the first modern coherent theory of the physical universe had been presented, scientific knowledge was applied to practical fields, science was accepted as basic to progress, and science was "popularized," accepted by non-scientists. The impact was wide-spread, affecting thinking about religion (the nature of the relationship between God and man), and leading to the view that the universe was an orderly, rational place where ideas could change man--thus the foundations of belief in free, democratic institutions.

32. Prophets of a Scientific Civilization: Bacon and Descartes pp. 287 - 292

A. Science before the Seventeenth Century
   1. Leonardo: universal genius but isolated, ideas not transmitted
   2. **Skepticism**: belief no certain knowledge could be reached: **Montaigne**
   3. Tendency to over-belief
      a. Lack of dividing lines between chemistry/alchemy, astronomy/astrology
      b. Charlatans: Nostradamus and Paracelsus; belief in witches

B. Bacon and Descartes
   1. Both doubted non-religious beliefs of preceding generations. They ridiculed faith in ancient texts. Medieval Scholastic philosophers had embraced Aristotle so enthusiastically that they neglected to subject his ideas to tests. Likewise, they rejected the deductive, rationalistic, logic of the Scholastics (which proceeded from definitions and general propositions to deduce logically). Deductive logic was replaced by inductive reasoning, in which truth is revealed by experimental testing and investigations of hypotheses.
   2. **Francis Bacon** (1561-1626)
      a. Bacon wrote *Novum Organum*, in which he insisted on inductive reasoning, from the concrete, particular to the abstract, general; rejected traditional ideas and preconceptions; and favored **empiricism**, with knowledge to be derived from observation and experience. He also wrote *New Atlantis*, portraying a scientific utopia where there was no break between pure science and technological invention
      b. Bacon had no influence on actual science; he lacked knowledge of the new work being done in his time; and he failed to understand the role of mathematics, which involves deductive logic rather than empiricism.
   3. **René Descartes** (1596-1650)
      Descartes was primarily a mathematician, founder of co-ordinate geometry; believed nature could be reduced to mathematical form. He wrote *Discourse on Method* in which he advanced the principle of systematic doubt. ***Cogito ergo sum*** was the basis for his logical proof of God. From this came his Cartesian dualism, a system of two realities: subjective experience, mind and spirit **and** extended substance, all outside the mind and thus objective--occupying space and thus quantifiable, reducible to formulae and equations. But he agreed with Bacon that science should lead to a practical philosophy to enable mankind to become "the masters and possessors of nature.

33. The Road to Newton: The Law of Universal Gravitation pp. 293 - 300

A. Scientific Advances:
   1. With the increased trade and travel of the Age of Exploration, botany boomed, often for purely utilitarian motives.
   2. An intensive, open-minded observation of anatomy began by 1500. **Vesalius**' *De Fabrica (On the Structure of the Human Body)* (1543) replaced reliance on the often inaccurate work of the Hellenistic scientist Galen (2d century AD). The work of English physician William **Harvey**, described in *On the Movement of the Heart and Blood* (1628), established the notion of blood circulation. Using the new

microscope, Malpighi identified capillaries in 1661, and **Leeuenhoek** observed and recorded blood corpuscles, spermatozoa, and bacteria.

3. Mathematics developed rapidly with the spread of Arabic numerals, the introduction of decimals and algebraic symbols, and finally the development of logarithms by **Napier** in 1614. **Descartes**' coordinate geometry, Pascal's theory of probability, and the invention of calculus by **Newton** and Leibniz were of immense importance to science in general and astronomy and physics in particular.

B. The Scientific Revolution: Copernicus to Galileo

1. According to **Ptolemy**, a Hellenistic Greek of 2d century AD Alexandria, the universe was earth-centered, with a cosmos of solid earth, crystalline spheres, fixed stars, and the empyrean, home of angels. All beings were ranked in a hierarchy of ascending perfection. The theory clearly fit theologically, but it was also believable scientifically. It was formulated in precise, mathematical terms, and though exceedingly complicated, it worked.
2. **Copernicus** (d. 1543), *On the Revolutions of the Heavenly Orbs* (1543)
   Copernicus based his ideas on the new theory that numbers were the key to nature and that simplicity was the sign of truth. His observations showed that another Hellenistic idea was to be preferred to the Ptolemaic: A sun-centered universe with revolving planets and an earth rotating on its axis. Yet while the theory was simpler, it provided too drastic a shift to be acceptable in an age of theological controversy (Reformation). Besides, the greatest expert of the day, Tycho **Brahe**, observed significant flaws. Round One to Ptolemy.
3. Johannes **Kepler** (1571-1630) managed to clean up Copernican errors by showing that planets moved in elliptical orbits. His revised theory was simple, had clear proof in mathematics, and it could be tested by observations. The "real world" did correspond to the purely rational world of mathematical harmony.
4. **Galileo** (1564-1642): provided further proof of Copernicus through observations begun using his new telescope in 1609--the moon had craters, the sun had spots, Jupiter had moons clearly rotating, and the stars were clearly much further away than had been thought. Galileo also suggested the uniformity of matter in the universe. He proceeded to develop mathematical laws of motion on earth--falling bodies, dynamics/inertia. These ideas shattered notions based on Aristotelian logic and long accepted by the Church as the truth. And Galileo, fiery and stubborn, was not the one to remain quiet about his findings. Though many leading churchmen quietly agreed with Galileo, Mother Church condemned the new heresy and banned Galileo's book, *Dialogue on Two World Systems*. When Galileo refused to keep quiet, the Church tried and convicted him, holding him under house arrest until his death. But the book was published, in Protestant Holland.

C. The Achievement of Newton: The Promise of Science

l. **Newton** (1642-1727) brought Kepler and Galileo together by proving why planets tend to fall to the sun and thus moved in elliptical orbits. He showed that gravity was a form of universal gravitation. In his *Principia Mathematica: The Mathematical Principles of Natural Philosophy* (1687) he showed that all motion could be described in the same formulae: moving as if every particle attracted every other particle with a force proportion to the product of the two masses, and inversely proportional to the distance between them. The theory required calculus, new measurements of the earth's size, and experiments with the pendulum.
2. Newton's work led to chronometers and the ability to precisely determine longitude; map-making (cartography) became a science. Math (and better metallurgy) produced much better artillery (aimed more precisely with the aid of calculus). Artillery meant warfare was more expensive--with advantages to larger nations with more efficient central governments. Improve firearms also gave Europeans a major advantage over non-Europeans. Steam power also resulted from improvements in science: Scientists, mechanics, and instrument makers combined to produce the steam engine--with a practical non-scientist, Thomas Newcomen finally putting all the pieces together (and getting all the credit, not to mention the cash).

D. The Scientific Revolution and the World of Thought Man was no longer the center of creation; the sky itself was shown to be an illusion. Science made clear a universe of terrifying size and silence. Yet it also produced a confidence in the power of the mind to discover universal laws--and contributed to the secularization of society. Religion was to decline, with science reassuring man that his universe was reasonable, orderly, and rational. Man could aspire to make human society equally orderly and rational.

34. New Knowledge of Man and Society pp. 300 - 307

A. The Current of Skepticism

The inter-relationship of Europe and the world brought new medicines and new diseases, plus new wealth, new foods, new products. Knowledge of the variety of human types and human customs and cultures tended to undermine old thought. As philosophers (or social scientists) viewed human diversity, they gained a sense of the relative nature of social institutions. It became much harder to believe in absolute values, that one set of human values or institutions was more likely to be God-given than another. Jesuit missionaries, the most traveled of educated men, stressed natural goodness and alertness of the peoples they contacted. Others came to praise non-Christian religions for their virtues. Perhaps the most important Skeptic was Pierre **Bayle** (1647-1706); his *Historical and Critical Dictionary* showed the gullibility of people and the problem of distinguishing truth from opinion and stressed religious toleration. "For Bayle, as for Montaigne, no opinion was worth burning your neighbor for."

B. New Sense of Evidence

l. In English law, new rules of evidence were put into use, with less discretion by judges. For example, hearsay evidence was not allowed, and accused were allowed legal counsel. Confessions could not be extracted by torture--and there was a new search into the validity of confessions in general. But torture continued to be used in Europe.

2. Historians began to insist on evidence and turned to greater use of archival sources. The science of authenticating coins, manuscripts, etc. was begun. Others began to rethink the age of the world. James Usher, Anglican bishop of Ireland, declared the Creation dated to 4004 BC (a date still used by some fundamentalists). A scholar announced the earth was 170,000 years old, a figure seen as fantastic and appalling.

3. Catholics adopted the Gregorian calendar (Gregory XIII) in the 1500s, though Protestants continued to use the Julian. The English adopted the Gregorian calendar in 1752, but the Russians did not until 1918. (in both cases: Why?)

C. Scholars worked in Biblical criticism, applying basic ideas of textual criticism to the New Testament. Other critics began denying miracles because of their faith in the regularity of nature and faulty human credulity.

1. **Baruch de Spinoza** (1632-1677) was most upsetting to the faithful. He was a scientific humanist who stated that God and the World are not separate. He rejected revelation and all revealed religion; he believed one should live his life based on a stern, pure ethical code. Scarcely read because of his "impiety," his ideas spread slowly.

2. **John Locke** (1632-1704) was more reassuring, and thus more widely read. He favored an established church, but called for toleration for all but Catholics (seen as adherents of a foreign power) and atheists (lacking a basis of moral responsibility). His Essay *Concerning the Human Understanding* (1690) stated that all knowledge is derived from sensate experience, since the mind at birth is a ***tabula rasa***. He believed the environment was all-important; all crime, false ideas, and superstitions came from bad environment, (including bad education and bad social institutions). His ideas became the basis of confidence in the possibility of social progress, with government playing the key role.

35. Political Theory: The School of Natural Law pp. 307 - 313

A. Political theory is practical, for it deals with what IS rather than what OUGHT to be. Machiavelli began by ignoring the Scholastic notion of what is the "best" form of government to examine how rulers actually behaved. He noted that they worked on one principle: what advanced their power, without concern for morality. The seventeenth century returned to the classical notion of **natural law**.

B. Natural Law "held that there is, somehow, in the structure of the world, a law that distinguishes right from wrong....[and] that right is 'natural,' not a mere human invention. This right is not determined, for any country, by its heritage, tradition, or customs....All these may be unfair or unjust. No king can make right that which is wrong. No people, by its will as a people, can make just that which is unjust. Right and law, in the ultimate sense, exist outside and above all peoples." Man is rational and can discover natural--or universal--law by his reason. Attempts were made to create international law based on natural law (Grotius and Pufendorf), but in the long run, little has emerged. Ironically, both absolutism and constitutionalism have been justified by reference to natural law.

C. **Thomas Hobbes** (1588-1679): Disliked the disorder and violence of civil war. He concluded that man "in a state of nature" lacked even the rudimentary ability for self-rule; that he was quarrelsome, vicious, and brutal, and his life was "solitary, poor, nasty, brutish, and short." Out of fear, men made a contract: a ruler was given absolute power to enable a maintenance of order. Absolutism was to produce civil peace, individual security, and the rule of law. Absolute power was an expedient to promote the individual welfare--not as a means to a totalitarian state. (***Leviathan***)

D. **John Locke** (1632-1704) agreed that government was a contract, but man was inherently good, only hindered by lack of public authority. Man had inalienable rights--life, liberty, and property. By his own power he could not protect his rights, so he set up a government to enforce the rights of all. The contract has mutual obligations; if the ruler violates them, he people have the right of rebellion. Locke took a specifically English event (the Glorious Revolution) and gave it universal meaning, influencing many later thinkers. He carried over ideas that were basically medieval, but in a specifically secular way. (***Two Treatises on Government***)