6 – The Scientific View of the World

It would be difficult to overestimate the importance of the Scientific Revolution to the history of humanity. To many historians, the advent of a mathematical, scientific view of the world marks the beginnings of our modern age. For centuries, the achievements of ancient Greece and Rome had established the standard of excellence and reference point for all knowledge. However, during Europe's Age of Genius in the 17th century, scientists and philosophers demonstrated that this classical heritage could be surpassed through the application of the scientific method. Scientific thinking has come to infect almost all intellectual disciplines; the result has been not only improvements in technology but the challenging of traditional religious, political, and intellectual perspectives. Modern science represents an intellectual tool of great power, though a . power that can also be used to destroy.

Chapter 6 addresses the following Key Concepts from the Course Description:

- KC 1.1 The theories and methods of the Scientific Revolutlon and persistence of beliefs in alchemy and astrology.
- KC 1.5 Debate over women's involvement in science; folk beliefs of causation.
- KC 2.1 State patronage of science to promote its interests.
- KC2.3 Development of political theories based on natural law

The Old Science

• THEME MUSIC

The bulk of this chapter addresses the OS theme; in fact, the Scientific Revolution establishes its central narrative, in that it provides the "objective knowledge" framework and demonstrates the power of scientific thinking to surpass ancient knowledge.

Prior to the 16th century, scientific thinking about motion, the cosmos, and the human body was dominated by Aristotle (4th-century B.C.E. philosopher), Ptolemy (2nd-century Greek astronomer); and **Galen** (2nd-century Greek physician). In essence, the worldview of these ancient Greeks was *qualitative-humans* could employ their logical and rational capacities to determine the nature of objects, and from there, describe their behavior. Greek thinking was absorbed into Christianity in the 13th century with Scholasticism, which thereafter dominated the investigations of natural philosophy, as science was usually called. Scholastics dealt first with definitions and general propositions and went on to deduce further structures of knowledge from these, including properties of the natural world.

Systematic observation, experimentation, and ***mathematics*** played a limited role in the Scholastic system. Therefore, the Aristotelian-Ptolemaic view of the cosmos relied on the "logical" view that the earth lay at the center of the universe with the moon, sun, other planets, and stars revolving around it along crystalline spheres in perfect circles. The heavens were made of a separate substance (the quintessence, or fifth substance, to distinguish it from earth, air, fire, and water) and moved in circles, because the sphere represented the perfect geometric shape, reflecting the perfection of the heavens. Earthly objects moved along straight lines and fell toward earth, not because of a mysterious force called gravity, but to be at one with the substance from which they were made. Each object demonstrated properties unique to its nature; thus, heavy objects were believed to fall faster because they contained more matter and thus moved more quickly to their natural resting place. Though the ancient Greek philosophers Pythagoras and Plato did believe mathematical harmonies underlie all of nature, ancient and medieval scientific thought did not contemplate the notion of universal laws that could be expressed through mathematical *equations.*

Ancient cosmology was reflected in views of human anatomy. Galen postulated that the human body contained four humors: blood, phlegm, yellow bile, and black bile. Each of these humors was associated with a particular temperament, so individuals dominated by blood, for example, tended to be sanguine, or optimistic and cheerful. Bodily disorders arose from an imbalance of humors. Treatment involved correcting this imbalance through purging (inducing vomiting) and bleeding. Regardless of these treatments' failures, such ideas held sway among physicians for centuries, whose studies revolved more around reading ancient texts than anatomical study or clinical work with patients. Church prohibitions on dissection probably hindered anatomical knowledge in this regard; though Leonardo da Vinci violated this taboo, his detailed sketches of the human body, as well as other amazing diagrams of flying machines, led to few practical consequences, as they were not pursued systematically or taken up by future scientists.

Several factors stimulated the development of new scientific approaches in the 16th century: the Renaissance interest in nature, the need for celestial navigation to support exploration, and the Catholic Church's interest in an accurate calendar. Though the old model had worked well for centuries, the discrepancy between its theories and actual observations grew, and could not be explained satisfactorily by continued reference to its assumptions.

Advances in Astronomy and Physics

There are moments when ideas can change the world – literally. Such was the case with **Nicolaus Copernicus**'s (1473-1543) *On the Revolutions of the Heavenly Spheres,* published just before the author's death in 1543.A Polish Catholic priest, Copernicus was called on by the church to develop' a more accurate calendar. He presented the notion of a heliocentric, or sun-centered, universe as a mathematical supposition. Though Copernicus retained many features of the Ptolemaic cosmology ("model of the universe"), this radical notion that God's special creation – humans and their terrestrial home – were no longer the center of the universe served to spark criticism and further astronomical inquiry. The developments that follow in astronomy and physics represent the primary field of advance during the Scientific Revolution; as you review, consider the relationship between new *ideas* and new *methods.*

The work of Copernicus demonstrates how a mathematics-driven astronomy could lead to and support new theories of planetary motion. Copernicanism temporarily stood as a theory without support from observations. Danish astronomer Tycho Brahe (1546-1601) provided these observations, as he spent over 20 years staring at the night sky on the isolated island of Hven off the coast of Denmark-all without the aid of a telescope! In 1577 Brahe charted the path of a comet that seemed to be traveling in an irregular (not circular) path as it passed through the supposed crystalline spheres, something that wasn't supposed to happen under the Ptolemaic system. While Brahe never fully accepted the heliocentric theory, his massive collection of data aided future scientists.

One of history's greatest scientists, **Johannes Kepler** (1571-1630), put Brahe's data to good use. Formerly Brahe's assistant, Kepler became court astronomer to the Holy Roman Emperor, despite being Lutheran. He used his mathematical genius to make a conceptual leap regarding planetary motion: many of the anomalies in the Copernican system were eliminated if the planets traveled in elliptical paths. Further, Kepler articulated three laws of planetary motion, all of which could be expressed precisely using equations. For example, Kepler demonstrated that the closer a planet orbited to the sun, the faster it moved, which fit with observations. Nonetheless, not all Kepler's view would be regarded as scientific today. Something of a religious mystic, Kepler believed that the orbits of the planets expressed a cosmic harmony, which could be heard in the "music of the spheres."

Galileo Galilei (1564-1642) combined interests of wide scope with an ability to attract patronage and attention, not all of which was positive. First, the Italian scientist's correspondence with Kepler demonstrates the emergence of an international scientific community. Second, based on repeated experiments, Galileo devised one of the first mathematical formulas to explain and predict a natural phenomenon, the law of accelerating bodies: 32 ft/sec/sec. Providing **empirical** ("based on the senses") support for the heliocentric theory represents Galileo's most famous contribution to science. In 1609 Galileo created one of the first telescopes and trained it on the heavens. The resulting *Starry Messenger* (1610) depicted the moon with an imperfect and rough surface, sunspots, millions of stars, and moons , orbiting Jupiter-all of which contradicted the notion of perfect heavenly bodies, the limited and static size of the universe, and that all bodies rotated around the earth. Despite ail agreement with the papacy to teach ***heliocentrism*** as only a theory, Galileo later published a clear endorsement of it with *Dialogue Concerning the Two Chief World Systems: Ptolemaic and Copernican* (1632), which landed him before the Roman Inquisition in 1633. Galileo remained a Catholic who believed in the unity of truth-scientific and spiritual-and that any conflict between them required it reappraisal of biblical passages in light of new discoveries. In the midst of the Thirty Years' War, the Catholic Church silenced Galileo . (placing him under house arrest for the next 9 years) and thereby stifled intellectual life in Italy for the foreseeable future.

• SKILL SET

Intellectual frameworks involve an approach or method toward knowledge (epistemology) and a model of the universe (cosmology) , to be Investigated, which explains the objects and forces that inhabit it and how causation occurs. To reinforce your understanding of the transformation wrought by the new science, consider diagramming the ancient/medieval and modern epistemologies and cosmologies. Use the content In this section to make sure you understand how they compare (COMP) and how they changed during this period (CCOT).

• EXAMPLE BASE

Whenever you encounter a series of example~, like the scientists here, it Is important that you go beyond rote learning. To sharpen your focus, consider these interpretive questions: How revolutionary was the new science? To what extent did thinkers retain traditional approaches or ideas?

Galileo's ideas could not be silenced, and his death in 1642 also marks the birth of the last great thinker of the Scientific Revolution – **Isaac Newton** (1642-1727). One of the true geniuses in history, Newton combined profound conceptual insights, precise mathematical expression, and systematic observation. Newton synthesized the work of over a century into a coherent view of the world, based on universal laws, as expressed in his *Principia Mathematica* (1687); as he later said, "If I have been able to see so far, it is only because I stood on the shoulders of giants." All objects behave similarly, according to Newton, because they all obey three laws of motion. What previous astronomers had observed piecemeal and with speculation, Newton synthesized into a cosmic machine, held together with the universal law of gravitation. In addition, to explain infinitesimal changes in motion, Newton invented a new form, of mathematics – calculus. With these tools, the universe could now be viewed as a finely calibrated watch that obeyed natural laws with mathematical precision, which allowed it to be explained and controlled by human reason. Though Newton was a deeply religious man who retained the image of God's will behind all, his cosmology helped separate the world of matter from that of spirit, setting the stage for deism in the future (see Chapter 9).

Advances in Anatomy and Medicine

In the same year that Copernicus introduced his heliocentric theory (1543), Flemish anatomist ***Andreas Vesalius*** (1514-1564) published the landmark book in his field – *On the Fabric of the Human Body.* Based on dissections and precise drawings, Vesalius contradicted many of Galen's ideas regarding the human body, again by employing direct empirical evidence. Building on this success and working for years in a laboratory, the English physician **William Harvey** (1578-1657) developed the modern theory of blood flow, with arteries and veins circulating oxygen through human tissue.

Further discoveries in anatomy were greatly assisted by the development of the ***microscope***, which became the basis for the investigations of a Dutch nobleman, Anton von Leeuwenhoek (1632-1723). For his discoveries of blood corpuscles, sperm, and bacteria (it was not linked to disease until later), Leeuwenhoek is often given the title, Father of Microbiology. Leeuwenhoek also corresponded with a secretary of the Royal Society of London (see below), Robert Hooke, who published his own book on the subject, *Micrographia* (1665) and worked with the chemist Robert Boyle (1627-1692). Boyle's book, *The Sceptical Chemist* (1661), criticized the blending of alchemy (the art of attempting to turn metals into gold) with chemistry, which should involve the scientific investigation of nature's most basic substances-the elements. In addition, Boyle articulated his famous law whereby the temperature, pressure, and volume of a gas can be related according to a mathematical formula.

Though these developments provided a mote modern understanding of the human body and its functions, they did not translate into improved medical care for some time. In fact, many physicians continued to receive their training in the traditional classical style – reading Galen and Hippocrates, rather than through experimentation and clinical practice. Hospitals in the 17th and 18th centuries were as likely to house vagrants as the sick. Given the lack of understanding regarding bacteria and germs, hospitals generally served as places for the ill to die, not to be cured. Faith healers, midwives, and barber-surgeons, who engaged in the traditional bleeding and purging regimen, continued to provide medical care for the vast majority of Europeans.

• THEME MUSIC

An often overlooked but essential issue of the PP and IS themes is demographics, .the study of populations. Modern societies have generally supported a higher standard of living and longer life expectancy. These accomplishments begin with improved understanding of human anatomy and disease. Trace relevant content throughout the course; this topic represents an appropriate starting point.

The Scientific Method: Bacon and Descartes

Modern scientific thinking was the product of two differing intellectual temperaments – the Englishman **Francis Bacon** (1561-1626) and the Frenchman **René Descartes** (1596-1650). Both shared a disdain for the Scholastic tradition and a skepticism toward knowledge claims that had not been demonstrated through a rigorous system of thought. Bacon, from a noble family and occupying important positions in government, advocated a scientific approach based on inductive reasoning. As opposed to the Scholastic tradition of working first with definitions and propositions, Bacon called for systematic investigation and observation of nature, as well as experimentation, leading to generalizations about the physical world. In his uncompleted three-volume work, *Instauratio Magna* (the Great Renewal), Bacon called for a new start to human knowledge, for humanity to put aside ancient preconceptions and prejudices and look at nature with fresh eyes. For Bacon, science should be useful to human beings; it should make their lives longer, more secure, and more comfortable. To demonstrate the great potential of science, Bacon published his *New Atlantis* (1627), which portrayed a scientific utopia and prefigured many modem technological developments. Though his ideas proved influential, Bacon himself did not fully appreciate the importance of theory and mathematics in scientific investigation.

A brilliant mathematician, René Descartes initiated the modem turn in philosophy. Descartes deliberately rejected Scholastic notions; his intellectual project subjected every assertion of knowledge to systematic doubt. The goal of his skepticism was not to reject knowledge *per se,* but to build a surer foundation for it. Descartes even doubted that he existed. However, though he could doubt the existence of his body (because his senses often deceived him), Descartes could not doubt the existence of his mind, for in the very process of doubting, he affirmed that he had a mind – "I think; therefore, I am" *(cogito ergo sum).* From this thought experiment, Descartes argued for dualism; the idea that nature is made of two basic substances-an intangible, thinking substance known as mind and a tangible, extended (taking up space) substance known as matter. Descartes also demonstrated the power of mathematics in scientific thinking. With *Discourse on Method* (1637), he argued for a ***deductive approach*** to knowledge, much like a geometric proof, moving from general principles to more particular cases by steps of reason. With his Cartesian coordinate system (x, y, and z axes), Descartes provided a precise abstract depiction of space useful for engineering, architecture, and the military arts. Some of Descartes' ideas were later proved wrong – he speculated that animals were like machines and felt no pain, and his unorthodoxy almost landed him in hot water with the Catholic Church. Nonetheless, Descartes stands as one of the great philosophers in history and initiated the separation of matter and spirit that marks the path of secularism in subsequent centuries.

• SKILL SET

All of the natural philosophers (the term "scientist" came into general use during the 19th century) of this era expressed religious beliefs and saw their work as partly spiritual, i.e., understanding the "mind of God," However, by establishing a mechanistic view of the universe guided by materialism and mathematics, they set the stage for new religious attitudes, such as deism, agnosticism, and atheism, Take note of how explanations of nature can have an impact on religious belief and the role of religion over time (CCOT).

Women and Science

Women contributed to science and, in turn, were affected by scientific thinking. Given social constraints, it is a wonder that any women were able to contribute to science. Women were excluded from universities, scientific societies, and generally received an inferior education. Opportunities were available, however. In Germany, for example, the craft tradition allowed women to work alongside fathers and husbands; as a result, 15% of German astronomers in the 17th and 18th centuries were women. One such was Maria Winkelmann (1670-1720), who discovered a comet before her husband and helped to prepare the astronomical calendar for the Berlin Academy of Sciences. Despite these contributions, she was denied admission into the academy. Maria Sybilla Merian (1647-1717) traveled to South America to study insects, and her subsequent text and illustrations, *Metamorphosis of the Insects of Surinam,* became a standard in the field of entomology. Emilie du Chatelet (1706-1749) translated Newton to make his abstract works accessible to a mass audience, while Dorothea Erxleben (1715-1762) became one of the first women to earn a medical degree from a university.

Unfortunately, these women proved exceptions. Institutional barriers remained strong, though attitudes served as an even more effective roadblock. Throughout the 17th century, philosophers, and scientists debated the *querelle de femmes* – the "women question." Ironically, some of science's greatest doubters-Spinoza, for example (see below) – could not extricate themselves from long-held prejudices when it came to women. Studies of anatomy seemed proof that women's smaller skulls and wider hips demonstrated their intellectual inferiority and fitness only for domestic roles. Investigation into human reproduction affirmed the greater importance of males in providing the "life force," with women providing only the matter or location of conception.1t was not until 1823 that the ovum was discovered, proving otherwise. Did women, then, experience a Scientific Revolution? On one hand, women did participate in scientific discoveries despite the obstacles, but on the other, "science" was used to corset women even more tightly in limited social and intellectual roles. When it came to women, science in the 17th century proved most unrevolutionary.

• THEME MUSIC

Once again, we see how a movement of cultural and intellectual change affected attitudes toward women and their position within society (IS). Continue to build on this theme as you study.

Religion and Skepticism

Though most scientists of the 17th and 18th centuries perceived no conflict between scientific inquiry and spirituality, the Scientific Revolution resulted in an increased skeptical and secular attitude. among European elites. At first, many scientists blended (what would today be considered) superstitious beliefs in ***alchemy and astrology*** with materialist and mathematical perspectives. As time wore on, educated Europeans demanded empirical evidence or conformity with natural laws for claims of knowledge. This new standard is reflected in the decline of ***witchcraft persecutions*** after 1650, which no longer received the support of those in positions of power. New standards of evidence eliminating torture and hearsay testimony, especially in England, provided a more scientific basis for legal proceedings. Furthermore, European colonization stimulated travel literature, which in revealing the diversity of human societies and customs suggested the possibility of cultural relativism. Following in the path of the French humanist and skeptic Montaigne (see Chapter 5), Pierre Bayle (1647-1706) examined beliefs from a wide range of human endeavors in his *Historical and Critical Dictionary,* only to conclude that most owed more to human credulity than to rigorous and rational thought. Bayle's work forms a bridge from the Scientific Revolution to the 18th-century Enlightenment (see Chapter 9).

Two thinkers stand out in their attempts to create a synthesis of the scientific ·and the spiritual. **Baruch Spinoza** (1632-1677) came from a family of Portuguese Jews forced to emigrate to the Netherlands as a result of the Inquisition. Beginning in the Cartesian tradition of dualism regarding substances, Spinoza came to reject Descartes' understanding of God and substance. For Spinoza, all of nature was ultimately one substance: all that we experience is simply a modification of that substance, which is God. We can conceive of this substance with the . attribute of extension (taking up space) or of thought (mind), but these attributes are ultimately manifestations of the same substance. Spinoza's substance monism made little sense to the Jewish community from which. he was excommunicated, or to orthodox Christians who thought it no better than atheism. Spinoza's rejection of an anthropomorphic God (in the form of humans) led him to a naturalistic view of human affairs and ethics. Even the title of his most famous work, *Ethics, as Determined in a Geometric Manner* (1677), illustrates his rigorous rationalist style. In rejecting miracles, holy books, rituals, dogma, and even free will, Spinoza left human beings . primarily with their minds to offer consolation, guidance, and whatever freedom comes from putting oneself in accord with the laws of nature.

Blaise Pascal (1623-1662) was a child prodigy of true mathematical genius. It is said that he independently discovered several theorems of Euclid's geometry at the age of 9. In addition, he later invented the first successful adding machine, developed Pascal's Triangle to show the pattern of ascending exponential functions of algebraic equations, and developed the geometry of solids as well as modem probability theory. After experiencing a profound religious conversion in 1654, Pascal gave up his work in science and mathematics for religion and philosophy. Pascal fell under the influence of the Jansenist movement in France, which rejected the Jesuits strong view of human freedom. In his famous work the *Pensées* ("Thoughts"), Pascal set out to show the proper relationship between reason and faith. Though scientific discoveries had demonstrated the insignificance of humans in the cosmos, Pascal nonetheless looked at human reason as a distinct capacity in the universe, or as he wrote, "Man is a reed, but he is a thinking reed." When it comes to religious faith, we will always want for evidence and arguments, said Pascal. Therefore, humans can weigh the alternatives---e.g., the promise of eternal reward vs. sacrifice of earthly pleasures according to Pascal's Wager and gamble on belief, for we have much to gain and little to lose with faith.

A Scientific View of Human Affairs: Law and Political Theory

Scientific thinking inevitably crept into human affairs. If matter followed natural laws, why could human behavior not also be explained according to the same laws? The birth of natural law philosophy and the concept of natural rights have grounded much of modem political development toward democracy and equality. Natural law holds that humans can discover what is fair, just, and natural in the political and social realms by consulting reason. Custom, tradition, or the edicts of kings cannot override natural rights, which inhere in human beings because of their unique capacities. For example, the ability of humans to speak, write, and create symbols suggests that they have a natural right to freedoms in these areas. In diplomacy, several 17th-century jurists, such as ***Hugo Grotius*** in *Law of War and Peace* (1625) and Samuel Pufendorf in *Law of Nature and of Nations* (1672), attempted to define rules for commerce and war based on the common good of nations rather than simply the might of the strongest. Even with international organizations like the United Nations today, the world continues to struggle with winning adherence by all nations to a code of international law.

Thomas Hobbes

Natural law can also be used to justify absolutism. A sophisticated and secular justification (compare with Bossuet's divine-right account in Chapter 7) of absolutism comes from **Thomas Hobbes** (1588-1679). Hobbes wrote his *Leviathan* (1651) amidst the Scientific Revolution and the English Civil War, both of which left their mark on his political philosophy. According to Hobbes, humans are born into a state of nature, in which life is a continual war of "every man against every other man" for gain, glory, and security. If humans are equal, it is only in their ability to destroy one another. Hobbes viewed human society as akin to a closed system of energy, which tends to dissipate (into anarchy) over time. The only solution. to this insecurity and chaos is for each individual to leave the state of nature by agreeing to a social contract with one another and with the sovereign, who will absorb the wills and power of each member of society into an all-powerful ruler. In the resulting commonwealth, the will of the sovereign (which could be a group of rulers) stands as law. Rebellion is prohibited, as it would only return society to the chaotic state of nature. Hobbes's justification is secular and scientific, and though it would be rejected by many in his native England, his notions of the state of nature and the social contract influenced subsequent thinkers.

• THEME MUSIC
Given the competitive environment of the European continent, states will seek advantages in many areas, science being one of them. For the SP theme, consider the factors that might affect a nation's political position related to science-commerce, navigation, and military weaponry.

John Locke

The most important defense of limited government based on natural law was written by the Englishman **John Locke** (1632-1704) to justify the Glorious Revolution (see Chapter 7). Locke's *Second Treatise on Government* (1689) takes Hobbes and stands him on his head. In Locke's state of nature, man freely enjoys his natural rights of life, liberty, equality, and property. These inalienable rights come *before* the development of human society. Though humans are basically rational, they still conflict in the state of nature over property. Such disputes create insecurity and reduce the enjoyment of one's liberties. Thus, individuals enter into a social contract and leave the state of nature to secure those rights. Governments are limited by their original purpose-arbitrating disputes and providing order and public goods. Should governments become abusive toward these ends, ' society can invoke the right of rebellion to secure those rights anew. In all, governments are made by people and must display features of the limiting social contract-representation, guarantees of rights, respect of property. Locke's ideas helped promote the unique development of England in this era, though it should *not* be viewed as an ' endorsement of modern mass democracy. Like Pierre Bayle, John Locke forms a bridge between the Scientific Revolution of the 17th century and the Enlightenment of the 18th century. Locke looked at the world from an empirical perspective, yet he believed that Christianity was a reasonable religion. At the same time, he supported religious toleration (except for the Catholics and atheists, whom he viewed as a threat to the state) as part of the settlement surrounding the Glorious Revolution. The ideas of Francis Bacon and John Locke form bookends to the 17th century regarding the importance of an empirical approach to the world. Locke became the foremost advocate of an empirical approach to knowledge in his philosophical writings. In *Essay Concerning Human Understanding* (1690), Locke rejected Descartes' notion of innate ideas, in favor of the mind as a *tabula rasa,* or "blank slate." Humans learn primarily from experience, which writes upon their minds and character their personality and knowledge. These ideas held radical implications when it came to education, as Locke argued in *Some Thoughts Concerning Education* (1689); children learn best not . from rote memorization but from experience and from "praise and esteem." Locke's wide-ranging interests and writings sparked new thinking in several fields, including child-rearing, education, politics, and philosophy.

Science Applied: Societies and Technology

• THEME MUSIC
Given the competitive environment of the European continent, states will seek advantages in many areas, science being one of them. For the SP theme, consider the factors that might affect a nation's political position related to science – commerce, navigation, and military weaponry.

Governments saw great promise in science. Prestige accrued to nations who sponsored great scientific discoveries, but more importantly, states hoped to exploit theoretical advances for navigational and military purposes. To this end, the first great scientific societies were formed in the 1660s. In England, the privately run Royal Society of London received a government charter in 1662; eventually, Sir Isaac Newton served as its president. Not to be outdone, Louis XIV chartered, under stricter government supervision, the French Academy of Sciences in, 1666.

Smaller or more regional societies, academies, and universities for the study and perpetuation of science were also founded in the century. These organizations held meetings, published journals, established research projects, and shared their results with scientists across the continent. Even if governments wished to monopolize science for their narrow national interest, it would not have been possible given the modern printing press. An international scientific community seemed necessary to the very nature of modern science; to ensure reliability, experiments had to be repeated, data shared, and theories confirmed.

Science can be of the most abstract nature; at the same time, all humanity shares an interest 4t its practical results. New scientific equipment and machines – telescopes, microscopes, barometers, globes, marine chronometers, pendulum clocks, improved cannons, early steam engines – promise greater human control of the environment. In subsequent centuries, Europeans would exploit these advances to the fullest. The results have been both the greatest period of human technological creativity and the most destructive conflicts in history.