HUMANITIES INSTITUTE
Frederic Will, Ph.D.

WESTERN EUROPEAN CULTURE - Science

Contents

ANCIENT PERIOD

Transition. We now know that scientific thought and method proliferated in China, millennia B.C. Also in Egypt, Mesopotamia, and Central America. But not in Europe—which had no such name, not to mention scientific skills—in the centuries which preceded the Roman Empire. In fact the areas we now call France, Spain, Germany were simple tribal cultures, with little infrastructure or communal development, in the millennia which preceded the Classical Age, and which led into the Fall of a great civilizing event, the Roman Empire.

POSTCLASSICAL (MEDIAEVAL) PERIOD

Empire. Thus it is that with the advent of that Empire, and of the Greek science it accumulated into its own, the Romans found themselves falling, at just the time when they were faced with 'foreign barbarians,' like Alaric, who were quite unprepared to value the cultural heritage of Rome. Out ahead of Roman science, in the wilderness of a shaggy empire full of foes, there lay lands in which the main concern was inevitably survival and not much more. From the considerable science Rome was itself ready to pass on, the new 'Christian' communities on the collapsed Roman frontiers were barely in a position to inherit much richness.

Rationalists. The major thinkers, of the early post Roman acculturation, were rationalists, people of cultivation and disciplined mind like Isidore.of Seville (6th century), the Venerable Bede (7th century), or Jean Buridan (14th century) who lived their relatively provincial lives from whatever scientific advances the Greeks and Romans had bequeathed them, but with nothing like scientific theory to guide them; unless it be the one overruling 'theory,' that the universe was shaped by the hand of God, and that the universe consequently shows order and harmony within it, if the observer looks carefully enough.

Necessity. By the later mediaeval period, the Renaissance of the l2th century, when art, architecture, and philosophical theory were maturing to a world level, the exercise of scientific intelligence was largely confined to the thinking of monastics whose interest in nature was, if keen, not analytical. That interest was driven by present need, to figure out what herbs had medicinal properties, the need to plot the movements of the stars, so that the date of Easter could be fixed. This latter need lay behind the inquiries of the Carolingian Renaissance, in part the result of an enlightened and inquiring ruler, Charlemagne. Under his inspiration, decrees were promulgated, authorizing the foundation of schools of learning, monastic or under the protection of a cathedral. Fresh and original concerns for science got expressed in such institutions. A new era was at hand, of intellectual readiness, for rich discussions from ancient Greek and contemporary Arabic texts.

Universities. In the last centuries of the mediaeval period the birth and spread of Universities proved the most effective seedbed of new ideas. By the year 1200 scholars and students possessed Latin translations of many major Greek authors—Ptolemy, Galen, Aristotle, Euclid—plus the available in-Latin works of Averroes, Avicenna, and Maimonides—all of which Muslim and Jewish material lay ready to hand in the rich Islamic caliphate of occupied Spain. A synthesis of talented Latin scholars—Robert Grosseteste, Roger Bacon, Albertus Magnus, Duns Scotus were at the center of a matrix of fresh conceptions of the natural world. The most notable of these twelfth and thirteenth century intellectuals was Thomas Aquinas. (1225-1274), declared ‘a doctor of the Church,’ whose rethinking of both Aristotle and Saint Augustine generated both the method and the sensibility required for a full understanding of the natural world. Two of Aquinas’ contemporaries, Robert Grosseteste—the founder of the Oxford Franciscan School—and Roger Bacon, laid great stress on mere observation, watching and thinking about the natural world.

Empiricism. While all these theologian scholars were empiricists, who directed their attention to observation of the natural world, Bacon laid out what they considered the operative method for interpreting natural phenomena. Observation, hypothesis, and experimentation were the three stages of a methodically effective account of nature and its phenomena. While the fruits of this method remained limited—equipment was rudimentary, and constructed experiments, as opposed to direct observation—intentions aligned with the increasingly effective work that lay just ahead, at the close of the mediaeval period.

EARLY MODERN PERIOD

Transition. The period we leave, at this point, is carelessly called ‘the dark Ages,’ a misnomer given the energy of study, not to mention the splendor of art and music, expended during the ‘mediaeval’ period, the ‘period in between antiquity and the modern,’ as it was viewed by many historians, from the eighteenth century on. The period we enter, correspondingly, is only by convention described as a Renaissance, a rebirth for the energetic opening out of the classics, the construction of real cities, the advancement of a nascent urban economy with ever more active trade—for indeed the makings of this situation were already to hand in the Late Middle Ages—for just those areas of trade, economy, international interactions, empirical investigation, which typically characterize the Renaissance.

Issues*.* Many of the questions of natural science, which concerned late mediaeval thinkers, flowed into the thought of the early Renaissance: one packet of concerns involves the trajectory of moving bodies, and the ambience of projection, resistance, and diversion which wants describing in any account of those bodies. Early Renaissance science, along with Grosseteste and Bacon, was one in excluding, from an account like the above, any reference to supernatural causality. The continuity of ages was just starting to weld together when the Black Plague (1348) came along and wiped out one third of the population of Europe. The thinking through of scholastic issues, such as the above, gave way after the disaster of plague to what we identify as a typical Renaissance fascination, with the wonder of mankind in a world no longer as directly shadowed by its creator.

Sequences. By the fifteenth century the Arab and Greek cultural wealth of Byzantium had begun to pass the Bosporus heading west, into the hands of Western European scholars, especially in Northern Italy. And there was other, and abundant, evidence that the world was changing, that man’s capacity to analyze and contextualize natural phenomena was growing. The seventeenth century willingness to think along the edges of new concepts was startling, and self-generating; with the increasing subsidization, and effectiveness of scientific undertakings—Vesalius *On the Workings of the Human Body*; *On planetary revolutions*, by Copernicus; Newton’s *Mathematical Principles of Natural Philosophy*; Galileo*, Dialogue concerning the two chief world systems*. Wherever the observant student turned, by the end of the seventeenth century, there were active investigations into realms of nature which required access by increasingly refined methods and tools.

EIGHTEENTH CENTURY

Advances. Diderot’s *Encyclopédie*(mid eighteenth century) incorporated his century’s headlong fidelity to the achievements of the preceding two centuries, and ushered in a period of mathematics, physics, and technology—Euler (infinitesimal calculus); Lomonosov, (conservation of mass in chemical reactions); d’Alembert (fluid mechanics; musical tonality)--these men were simply part of a phalanx of eighteenth century thinkers who were to herald in the evolved mathematical, biological, and cosmological thinking of the following two centuries.

Society. By the eighteenth century the major advances of science--in astronomy, medicine, physics--were not only factors of seemingly endless promise, but were diffusing into society, and meeting with a new audience of (in nascent form) popularized consumers. By an oversimplification, we might say that eighteenth century science, in Western Europe, was less original than seventeenth century science—the age of the worldview- changing studies of Copernicus, Galileo, Kepler, and Newton—or than will be the giant astronomical and medical strides made by the nineteenth and twentieth centuries; but then we would need to add that eighteenth century Western European science was a period of absorption, of the huge strides of its predecessors, and of plateau laying for its future. Broadly speaking the West European society was in the eighteenth century being acculturated to the new world of experimental science, of a universe orderly but god-free, of institutions—like monarchy and the Church—which were essentially fossils, and of course relatively 'understood' at last, so that man and society could be as enlightened as allowable for them.

Advances in scientific theory and practice were of course not stalled, during the century which preceded the French Revolution and the Napoleonic era. Those significant advances—in math and physics, in medicine and biology, in the understanding of electricity—were themselves fed into the growing *awareness* of the sciences, which was finding its way out to a broad public—a public of rapidly growing literacy, of increased mutual interaction, and of ever higher expectations, for the quality of its daily life. This growing public was one in which university level education was increasing rapidly, in which Academies of Learning were springing up throughout Europe, in which public lectures—widespread, from coffeehouses to municipal centers—were becoming a part of civic life, in which dictionaries and encyclopedias were available in bookstores and libraries, and in which popular books on Newton's laws of physics were available around the corner.

Universities. Science (physics, chemistry, geology, zoology, anatomy) was typically taught, in 1700, under the heading of natural philosophy--in the one hundred and five Universities open in Europe. In these Universities not only were 'the sciences' taught, but the lectures given were typically—as had not prior to 1700 been the case—accompanied with lab demonstrations, part of the bringing home to the culture the actual practices of the sciences. Throughout the nations of the continent, , Universities began to assume specialized roles: in France the instruction in science was increasingly carried out by Academies, like the French Academy of Sciences; in England Newtonian physics became a favored topic at the University of Cambridge, while the Scottish universities were renowned for medical studies; German universities became renowned for the liberty they provided their science faculty to plan their own courses: in return for which there was already a strong implicit demand for faculty research and writing in the sciences.

Academies and Journals. Mention was made of the French Academy of Sciences. The fact is that academies of and for scientific learning and sharing were surging upward in all the major capitols and university strongholds throughout Europe. With that rapid growth developed a market and taste for learned journals, by which by century's end every branch of science was able to find specialized expression, and to introduce itself, so to speak, to the ever larger reading public.

Dictionaries and encyclopedias. As with journals, encyclopedias and dictionaries began to occupy the shelves of bookstores, as well as of privileged private homes. (The same comfortable residents were by this century likely to be daily readers of the newspapers which were now the talk of the town in the cafes of all large European cities.) For sake of example, and because the example was of world wide importance, one can think of the *Encyclopédie* (*Encyclopedia or explanatory dictionary of sciences, arts, and crafts)*, which was edited (and in part written) by Denis Diderot and Jean d'Alembert, and which began publication in l751. The final publication consisted of 71,000 separate entries, and was distributed over thirty five volumes. Many of the entries dealt with specifics of sciences and crafts, so that the work as a whole could be used both as a scientific reference work and as part of a continuous text dealing with the acquisition of knowledge by the animal man.

NINETEENTH CENTURY

Science. In 1833 William Whewell coined the term *science*, a term wrapping up the bundle of inquiries—chemistry, physics, astronomy, biology, anatomy—which had formerly fallen into diverse categories, with particular favor toward 'natural philosophy,' a term linking this set of inquiries to the broad categories of human investigation congenial as far back as the Middle Ages. We were in l833 still far from today's*trivium,*which includes humanities and social sciences, along with the natural sciences, as the framework for our knowing of the world.

Harvesting. If the seventeenth century opened vast inquiries into the skies, the movements of the planets, the relation of earth to the cosmos, the movement of the blood within our bodies; and the eighteenth century brought these bold methodological inquiries into*social awareness*, the nineteenth century can be characterized by its probing of specific realms of natural and mathematical inquiry—its concern with evolutionary biology, higher math and its application to physical processes, electrical currents, their structure in electromagnetic processes and their ultimate uses In such devices as the telephone, and such beneficent insights as the germ theory of disease. Through its multiplying and ever better equipped facilities—labs and institutes—the science of nineteenth century western Europe was harvesting hard won discoveries and disseminating them through the increasingly democratized and prosperous middle class of a rapidly growing western Europe.

Darwin and Pasteur. Charles Darwin's *Origin of Species*, which combined extensive world travel and observation, with the highest grasp of data-implications, offered mankind a glimpse of his developmental history, and inspired a reorientation, disorienting to many of the orthodox for its implication that we are 'higher apes'. Pasteur took us into the germ theory of disease, instructing us proactively how to take care of ourselves. He also invented a vaccine against rabies.

James Clerk Maxwell, and a host of fellow investigators, made advances In understanding the properties of electricity, among them electromagnetism and, with the input of brilliant mathematicians, the laws of thermodynamics and the principles needed for the construction of all manner of electrical motors, the basis for everything from our fans to our cars.

Gauss, Boole, Cantor. The study of mathematics grew increasingly abstract, and at the same time unpredictably practical, in the course of the nineteenth century. Carl Friedrich Gauss contributed to a fundamental understanding of algebra and geometry. Georg Cantor laid the foundations of set theory, which would play a creative role in symbolic logics. George Boole thought through to what we call Boolean algebra, which has proven essential to the construction of the personal Computer.

TWENTIETH CENTURY

Globalism. The omnipresence and often culturally modifying presence of science, and of what science makes possible, is perhaps the determining characteristic of the history of Western Europe. (We will stick with European examples, here, but it should be noted that the scientific achievements of the United States—and many other developed countries—were by the twentieth century completely intertwined with those of Europe.) The internet, one of those creations of science, is one forceful reason why work in the sciences is no longer confined to any single nationality.

Immersion. The immersion of the twentieth century citizen, in the complex discoveries and creations of science, can for our purposes divide into two categories of experience: 'discoveries' and 'technologies,' where technologies will mean tools, and 'discoveries' will be new knowledges or programs of understanding.

Technologies. For the ancient Greeks,*techne* (art, skill) and *technologia* (technology), denoted lesser accomplishments, like the makings of the person who works with his hands. This kind of labor, readily contrasted with work of the mind (*nous*), was expected of subordinates, or at best of what at the time would have passed for engineers, who worked with the face of nature, to modify it. The work of wisdom, theory or*philosophia*, was devoted to gaining intellectual grasps of the human condition or of the broad world of the human. In the terms of our own day, which has revalued the relation of tech to wisdom and understanding, both theory and tool are treasured, but what strikes us most is the proliferation of the tool—which of course impacts us where it counts, in our adjustment to the practical uses of 'being-in-the-world.' As we sit plucking at our laptops, reaching out for a sip of powdered java from our plastic cup, then rise to turn off the light in the study and to toddle upstairs to our nylon pajamas and processed cotton bedsheets, we harvest the labor of many cunning 'technologists,' the men and woman paid for their labor, in our time, to fashion matter into useable new life-tools for a facility-loving new version of *homo sapiens*.

'Higher sciences,' 'Discoveries.' Experiments devoted to ferreting out the human genome and tracking DNA; observations and conclusions concerning the nature of time and the relativity of time to the position of the observer; the exploration of the foundations of geometry and algebra; the parsing of the implications of quantum mechanics which, like relativity theory, requires readjustments of perspective even on the 'common sense' level of daily life-interpretation: all these upgraded expectations, for those who want to understand and in many instances to employ, the world we're in, derive from great scientific pioneers, the majority European, who in the twentieth century carried their post-Renaissance history to formerly unimagined limits.

Suggested readings
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Park, Katherine, and Lorraine Daston, Cambridge University Press History of Science, Vol. 3, *Early Modern Science*, Cambridge, 2006.

Sandursky Samuel, *Physical Thought from the Presocratics to the quantum physicists*, Pica Press, 1974.

Slotkin, Hugh Richard, ed., *The Oxford Encylopedia of the History of American Science, Medicine, and Technolog*y, Oxford 2014

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Discussion questions

Which branches of scientific inquiry have proven most fertile for human understanding? From which branches have we learned the most? Would you think of astronomy, which was so central for ancient cultures? Or medicine—which was already a branch of study in Medical Schools, in third millennium B.C. Egypt? Is physics the supreme growth area for our century? What does all this mean?

In the twentieth century we pride ourselves on our technological know how, whereas for the ancient Greeks, for example, technology—admittedly with a different sense—was looked down on as an inferior pursuit, devoted to the solving of practical, rather than mind-based, theoretical issues. Is there a reason for our prioritizing of technical achievements? From what sort of mind and culture did the inventiveness of Thomas Edison, the supreme 'inventor genius' arise?

Have we learned that science is truly a global pursuit.Is contemporary science, as practiced in Bangkok or Whtehorse or Tokyo, the same as the undergraduate science taught at Yale? What would account for the specific differences among these sites of learning? How practical was the science you studied in 'school'? Did you learn how to handle the real world? Or how to compute algorithms? Is the mathematical learning, in science, helpful for daily life? Should it be?