Science, Conquering Child of the Church

Jesse Ausubel and Cesare Marchetti

Possible chapter for The World's Progress
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The Christian West gave birth to technology and science in their present forms. We begin our inquiry about the future of technology and science by searching to reconstruct the conditions around them that made possible the birth and a successful childhood.

Technological spirit

Medieval historian Lynn White traces the origins of modern technology and science to a profound change in the attitude toward the external world that took form, with slow progression, between the 5th and 10th centuries. In the 7th century, Saint Benedict of Norcia emerged as a historic figure by establishing that his monks, inevitably intellectuals, would work in the fields. In the frame of Greco-Roman ideology, the decision was revolutionary. However, a Judaic precedent, that rabbis would earn their own living working with their hands, percolated into the Christian ideology. To make the religious types work, inevitably it was necessary to ennoble and sanctify tools and, later, machines. Machines came from god, machina ex deo, and thus were spiritual, said White. The Benedictine monasteries became for almost eight hundred years centers of development and diffusion of technology, agriculture and proto-industrial.

The Utrecht Psalter offers an early tangible sign of the new attitude in a miniature executed around 830 by a Benedictine monk. The miniature illustrates Psalm 63: "Those that seek my soul, to destroy it, shall go into the lower parts of the Earth. They shall fall by the sword; they shall be a portion for the foxes." A partially concealed line of the Just, armed and guided by King David in person, confront a more numerous armed group of the Wicked. Each of the camps sharpens a sword. The Wicked hone with an old whetstone. The Just in contrast employ a revolutionary machine, a grinding wheel. The winch for turning it appears here perhaps for the first time in the West and the machine in total for the first time almost certainly. That advanced technology provisions the Just through obvious divine concession is expressed with total clarity. Implicitly, the machine is the instrument of victory, that is, of power.

The absolute explication of the concept of the divinity of the machine appears around the year 1000 in Winchester in the illustration of a gospel inspired by the famous passage from Sages 11-10: Omnia in mensura et numero et pondere disposuisiti, "Thou hast

established all things by measure and weight and number." Here the hand of God, now a master builder, holds a balance, a wooden square, and a compass. The brave Winchester friar expressed himself well but perhaps overdid it. His new representation diffused, but in simplified form. God would hold in his hand only the compass, perhaps influenced by Proverbs 8-27: "When he prepared the heavens I was there: when he set a compass on the face of the deep." This representation, expressing the voluntarism of the West, never propagated itself in the area of Orthodox Christianity.

Action followed principles. Ingenious machines filled the Benedictine abbeys, above all machines using hydraulic energy. The Abbot Arnold of Bonneval recounted the construction of the monastery of Clairvaux in 1136 with a long list celebrating what hydraulic machines did: coquendis, cribrandis, vertendis, rigandis, lavandis, moliendis, molliendis, suum sine contradictione praestans obsequium: digesting, sieving, turning, crushing, conveying, washing, heaving, softening, without contradiction and with outstanding obedience. The holy machine was also a vehicle of Christian charity, relieving humanity of the difficulty of labor. The brothers amused themselves like madmen, even snubbing religious functions such that Abbot Rupert Deutz (d. 1130) scolded "those who do all in works of the hands."

This religious breath encountered a condition of great importance. Toward the end of the 1st millennium Europe was a continent besieged, its back to the Atlantic. Magyars, Muslims, and Vikings were on the attack. The prospects of survival for what we call Western culture were tenuous. Nevertheless, around 1000, the Europeans had defeated and assimilated many Vikings and Magyars and were counter-attacking Islam in Spain and North Africa. At the end of the eleventh century the Europeans were carrying the Cross to the Middle East. By the end of the 14th century Europe neared full vigor. Vasco da Gama, Magellan, and Columbus broke barriers across the oceans and in a generation the Europeans swarmed the world, exploring, doing business, robbing, and conquering.

Scientific spirit

The mechanism of construction of the technological spirit is clear enough. Current prejudices would persuade us to put science on the same plane, considering science as a form of abstraction from technological problems, like the thermodynamics of Carnot, and source of suggestions for applications. However, historical analysis shows that science and technology are two entities completely separated until the second half of the 19th century. Contacts may well have been continuous as, for example, the demand for ever more precise horology by astronomers stimulated much clever clock making. But contact does not signify osmosis of ideas.

Christianity here did not seem to play an explicit role. The first Christians were indifferent to the problems of science, as to the rest of Roman culture in which Christianity was soaked. The situation altered around 1100, after the conceptual rehabilitation of the machine. The first signs were a fresh interest for nature revealed in art, for example, gothic sculptures that copied vegetation realistically, in place of retracing patterns from school.

St. Francis, in the 1200s, said that natural phenomena have an intrinsic importance,

and all things in their manner honor God. This spirit pervaded the Franciscans and one of them, Roger Bacon, stated that the books of knowledge are two, the book of scripture and the book of nature. In fact, in the following 400 years, scientists continued to mix the two. Leibniz and Newton considered themselves good theologians, and even Galileo did not break the fetters.

The making explicit of the fundamental role of the book of nature may have played a role in the intense reaction of Christianity to the Cathar heresy. For the Cathars, as opposed to Saint Francis, the visible universe was created wicked. Clearly the Christian interest came to be to rehabilitate nature, to port it back to the initial creation of divine nature.

Once parted from metaphysical values, Western science flourished, rapidly assimilating everything that Greece, Islam, and the distant regions of India and China were capable of offering. But science remained natural theology: speculations and research without practical objectives.

Catholic rhythm

At this point, let us examine in an unorthodox way the internal dynamics of Catholicism. Our basic hypothesis is that religion represents a cultural trait and diffuses, following the paradigm of cultural diffusion. Suppose that a measure of intensity of faith is the production of saints. Saints measure the temperature of faith. The canonization of saints (number per 100 years) is then an easily measured, quantitative proxy. With saintly data, we can then employ methods we have used to study cultural diffusion in thousands of other cases, ranging from the spread of Cistercian monasteries, to steelmaking technologies, to recording media (records, tapes, cds) and computer chips. Relatedly, within science the number of works published about a certain subject evolves in time like the number of individuals who occupy a niche. The analytic technique permits us to construct a formal structure that faithfully represents the past and a certain portion of the future of the system.

To simplify the Catholic work, instead of digging into hagiography, we chose the saints mentioned in the calendar. There are 3 per day, so the database is about 1000 units. The first and unexpected result is that there are two diffusion waves, spaced about 1000 years apart, if we measure the distance in time through their central points, the dates of maximum speed of growth of the cumulative number of saints. The central points are located about 340 AD and 1360 AD. We call the first pulse Patristic for the fathers of the church and the 2nd Tomistic for Aquinas, who was active near the center of the 2nd impulse. Curiously, the total number of calendar saints splits almost equally between the waves.

Most impressively, the system for production of saints is perfectly self-consistent over more than 1000 years, as if history had not existed around it. Barbarians come and go; kingdoms grow and fade away, along with wars, pestilences, and geographical and technological discoveries. Nothing dents the explicit diffusion process. The result collides head-on with the current belief in the contingent nature of history.

Like a parabola describing the whole trajectory of a projectile, the data can be used to project backward as well as forward. Projecting the 1st pulse backward, we see the first pulse should be brought back to about 500 BC, that is the Christian movement was born about 500 years before Christ, rooted in the Jewish sects of the Servants of Yahweh and later

the Essenes. Christ in our eyes looks like Christopher Columbus, not an inventor but a later innovator who popularizes the invention and gets credit for it.

We also observe that the 2nd pulse is practically finished, having reached 98% of its saturation. If the pulse mirrors the history of the Catholic Church as an institution, then it is an at end. The Catholic clergy seems one year older on average every year, and may rapidly evaporate when old age enters the area of high mortality. Young people are not taking orders.

Science takes the baton

We may try to construct a third pulse for the Church. The simple rule is to keep the distance between center points constant. The next one should be in 1350 + 1000 or 2350 AD. The ratio of time constant delta T should also be constant. For the first two it is 750/640 or 1.17. The constant for the next pulse should be 640:1.17 = 546 or 550.

Let's try to guess the characteristics of the new pulse. It formal beginning (1% of saturation) is in 2350-550 or 1800 AD. The nucleation period, when the basic structures are conceived, will precede that. In the case of the Tomistic pulse, the beginning is located by the historians of religions at the time when Pope Leo 1 chose Rome as the seat of the papacy in 450 AD, about 250 years before the 1% emergence of the 2nd pulse.

If we apply a similar nucleation period to the third pulse, the starting period is between 1550 and 1600. This is the period of Galileo and Newton, when science began to start liberating itself from the confines of religion. Newton said discovering the laws of gravitation provided mathematical demonstration of God's working in the universe and as an aside the ultimate weapon in the war against irreligion.

If science and technology are so deeply ingrained in Christianity, why not assign them the next pulse? The dates fit well with the formation period of science, and we do not see any other object acceptable for taking the baton.

A third impulse centered in 2350 and with time constants adjusted to the earlier Catholic pulses fits well with the development of science that in a certain way has taken the baton of theology and natural theology. Certainly there is much religiosity in scientists' attitude toward the truth and in the moral discipline of scientists, even if openly agnostic. And in their adoration of the universe. The laws of nature are, in the ultimate analysis, accomplishments [gestures?? the body??] of Christ, like the clocks put in beautiful positions in Renaissance churches, an image of the order and rationality of the universe.

An object beyond imagination

Treating science as a profound, long-lived cultural impulse has various interesting consequences. Recall our discussion of the origins of technology and science. The unity of causes did not stimulate their marriage. The Franciscans dedicated themselves to the university and the Benedictines to machines. The Papal Bull of Benedict the 12th in 1336, in which he decreed that at least one Benedictine in twenty must go to university, had little effect. It seems that no medieval engineers studied at university. In Europe education of engineers was formalized only in the 1700s, and in technical schools separate from university. Polytechnics today still show the shadows.

A tie between technology and science initiated itself only toward the end of the 19th century, according to Lynn White as a consequence of the diffusion of democratic ideas. The direct clasp only happened with the Manhattan Project, during the 2nd World War, when pure scientists were put together to produce a very applied contrivance of nature, the atomic bomb. This marriage between mind and arm now gives fabulous results. In 50 years or so, a very theoretical discovery such as the laser reaches home in compact disks.

So, for technology as well as science we are just at the beginning. In 1800 we were at 1% of the development of science in terms of final saturation levels. Now 200 years later we are still at a mere 5% level. Multiplying the present stage by a factor of 20, whatever parameter we measure as a proxy produces an object beyond imagination. But, accepting a centerpoint of 2350, we still have more than 600 years to bring it to 90% completion.

Threats to science

Who is going to produce all the science? The United States acquired the scientific lead from Europe in the 1930s and has carried it to new and glorious levels, especially in California, where inhibitions are famously few. The United States and some of the other European offshoots, Canada and Australia, for example, still seem to be growing, at least demographically. Perhaps the former European colonies will maintain science for a century or two after Europe abandons it. Goa, in India, built baroque Portuguese cathedrals long after the metropole stopped. Latin America, which belatedly picked up the European form of the novel and made it flourish, magically, in the late twentieth century, might do the same for science.

Historian of science Derek de Solla Price argued that production of valid results grows as the cubic root of the expenses for research. In other words, producing double costs eight times as much. New nations, where the level of research is still low, may be bargains in terms of specific costs. India and China come to mind. But producing scientific innovation is not only a problem of education and funding; it is also a problem of religious or cultural outlook.

The aggressive search for knowledge and its application is perhaps the most significant contribution of Western civilization. The game began centuries ago but has reached completely new levels in the past 50 years, above all in the United States. Many industries have systematized their search for better practice and have the gains to show. The hard search is costly and requires skillful organization. And, we would emphasize, courage and confidence and the tolerance that can accompany them. Science, the structured and sanctioned overthrowing of authority, is the purest form of continuous improvement.

The Islamic world held the cutting edge of science until past 1100 A.D. Then it rejected the windmill and, later and repeatedly, the printing press. Loss of economic and political leadership followed. The objects of science, the technology, can be taken without the values. The corsairs of the Barbary Coast which raided British vessels for 50 years or so were in fact piloted by renegade Britons and Icelanders; when the foreigners died, their knowledge of sailing was rejected and forgotten. Voltaire noted that after 60 years of Swiss watch exports, no one in the Middle East could make or repair a watch.

So cultures can and do reject science. Or be excluded from it. Women have been.

Historian David Noble convincingly traces the exclusion to the clerical ascetic culture of the Latin church, which gave birth to modern science but only as a male vocation. The otherwise revolutionary Galileo, concentrating on his own calling and knowing the costs of raising and marrying daughters, contrived to place his two girls, aged 11 and 12, in a convent in the year 1613. Livia suffered a permanent breakdown. The second, Virginia, whom her father praised as "a woman of exquisite mind," dreamed of fathoming the heavens. She never left the strict enclosure of San Matteo in Arcetri, which did not permit her scientific pursuits.

In 1950, in the United States, one woman and 416 men received doctoral degrees in engineering, while five women and 353 men did so in physics. Today in the United States about one in six of doctoral students in engineering are women; the ratio is one in four in physical sciences and mathematics. In most sectors, the feminization of work and power is now well underway. While women provided about 15 percent of career years in the 1850s in the United Kingdom, they currently provide well over 30 percent. Science now seems likely to suffer if women reject it or it rejects women.

One can also imagine a shrinking Europe, whose residences fill with immigrants from the Mahgreb, who spread their culture, hostile to science. The 5,624 mills listed in England in the Domesday book of 1086 exceeded the mills in the Ottoman Empire at its height. The Far East remains a question. A Nature article entitled "Can Confucius Excuse Poor Creativity?" listed factors that seriously undermine Korean creativity. Then Nature queried, "And those who have returned from the creative hot—houses in the West? As soon as they return, it is said with a rueful laugh, they become Koreans again." Spengler perceptively characterized Western culture as "Faustian," symbolized by pure and limitless space, limitless striving and aspiration, its architectural symbols the soaring vaults and spires of a Gothic cathedral. Spengler particularly contrasted the West's Faustian culture with what he called the Magian, whose proponents dwell in a magical world of mysterious presences. Western culture had superseded the Magian around 1000 A.D., according to Spengler. For how long?

The point is that past changes in science have related to changes in basic religious attitudes, in aesthetic perceptions, and in social relationships, as well as to economics and politics. Along with money, science must have a positive emotional context to thrive. As White observed, the modern outburst of scientific activity is not necessarily permanent.

Conquerors of the structure of the possible

Whirling in the turbine of progress, many ask about technology and science, to what good? Or more egotistically, for whom does it create? Here it is useful to recall that even the idea of progress is in the Christian matrix. Christianity invented open time to avoid that the cyclicity of classical conceptions that would periodically recrucify Christ. And it was St. Augustine who proposed a manager to guide on this road toward the unknown, God himself, with a Providential program. The rays of reason liberate us from Providence, putting us then in the hands of Progress, which jealously conserves its attributes.

But of what does progress essentially consist? In the case of the evolution of life the answer is clear enough: structures always more complex can dominate problems ever more complex and better affirm their presence in the world. The control of complexity is thus the

most valid index of evolutionary level. DNA acts to modify the structures of the individual, and, for animals, the nervous system, eventually a brain, modifies behavior. For humans, syntactic language resumes the action of DNA with analogous quantitative mechanisms. Culture becomes the image of the genetic pool.

DNA has made splendid things that we can admire in livings beings. And the obvious visual and behavioral splendor is perhaps surpassed by the refinement of the mechanisms that scientific analysis keeps revealing. Here let us not forget humans with their syntactic language. This language has in fact permitted the human species to explore recesses of the possible inaccessible to DNA. No other living being has landed on the moon, or succeeded in controlling nuclear fission as a source of primary energy.

The profound formal analogy between the functioning of DNA in the manipulation of information and articulated language can explain the success in the use of models of biological competition of the Lotka-Volterra type for interpreting social phenomena, in particular in the areas of technology and science. In both cases, an idea that is born by the combinatorial mechanisms of the brain comes to be tested experimentally and, if a success, can diffuse internal to the system, in the same way that a mutant or a new species can diffuse inside an ecological niche, displacing the preceding species. So the auto displaced the horse, and the theory of relativity of Einstein displaced Newtoniana. Simple solutions of the Lotka-Volterra equations, often logistic, describe these processes of substitutions with ferocious precision. The mechanisms carry a determinism of which our will is the motor, but not the dominator.

Science and technology can thus be seen as conquering territory in the structure of the possible, as DNA has done for about 4 billion years. Their advance has all the characteristics of a territorial occupation. But what is the final scope of this work? Manfred Eigen about 30 years ago laid down the foundations of a mathematical model of evolution, showing that all laws can be deduced from the categorical imperative of survival, including the maximization of number. In this light, the final scope of science and technology is that of serving the technology of accessing of resources, to maximize the dimensions of the niche, that is carrying capacity of Earth, or indeed the Universe.

With appropriate technology to access resources and their use, existing today in practice or at the level of the laboratory, the carrying capacity of Earth could be valued at 1012t1î or a trillion persons, 150 times the present level. And this level can be attained without exhausting anything and without any pollution, given that people would have retreated in walled cities, autarchic except for the input of energy or negentropy that can be furnished by uranium and hydrogen. We site this example because it contains what may be a prime mover and final cause of all technological and scientific development: To know to dominate, and to dominate to render oneself independent of the system.

Recapitulation

Humans like Australopithecus were completely immersed in the biological system of the forests and savannah, and both depended on the negentropic flux of solar light, captured by

chlorophyll. Agricultural humans passed to control of the biological system, to augment productivity and consequently number. Technological and scientific humans could cut completely ties with the biosphere and construct an internal world. The primeval forest could tranquilly regrow for the amusement of naturalists. The walled city would then be the prototype of the spaceship ready to conquer the Universe. If our hypothesis fits the facts, we are just at the beginning of a great science and technology adventure.