History of Islam

An encyclopedia of Islamic history

Why Did the Scientific Revolution Not Take Place in the Muslim World?

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Summary: The natural sciences did not die out in the Islamic world with the Mongol devastation of the thirteenth century. Indeed, the Muslims held their own in art, architecture, astronomy and artisanship on the world stage well into the eighteenth century. It was only at the turn of the eighteenth century that Europe acquired a decisive technological edge and supplanted the ancient civilizations of Asia and Africa.

This article examines the complex interplay of intellectual, religious, social, political, economic factors and the decisive military events that precluded the onset of a scientific revolution in the Islamic world. Summarily, we find seven discernible milestones in the 1400 year long history of Muslims that influenced the development of science and technology:

- o The Mu'tazalite eruption and its aftermath (765-846)
- o Al-Gazzali's repudiation of the philosophers (1100)
- o The Crusades (1096-1240)
- o The Mongol Devastations (1219-1258)
- o Neglect of the printing press and naval technology (1450-1728)
- o The Destructive Shia-Sunni, Sufi-Salafi Controversies (700-ongoing)
- o Colonialism and the onset of the Age of Discontinuity (1757-1947)

The discourse tends to get obscure when questions of philosophy and science are discussed. Therefore, a number of resources from the open literature have been used to construct a narrative that is as accessible to a layman as it is to a scholar.

The Rockets of Mysore

It comes as a surprise to some readers that the American National Anthem, The Star Spangled Banner, was inspired by the rockets invented by a Muslim king, Tippu Sultan of Mysore, India. It was the year 1814. The Anglo-American war was in full swing. The British forces, after burning down Washington and conducting a raid on Alexandria, proceeded up the Chesapeake Bay to capture Fort McHenry in Baltimore. Caught in the cross fire were two American lawyers, Francis Scott Key and John Stuart Skinner who had gone over to negotiate a truce and prisoner exchange with the British. Key and Skinner were allowed to board the British flagship HMS Tonant and present their proposals to Major General Robert Ross and Vice Admiral Alexander Cochrane while the two were discussing their plans for an attack on Baltimore.

Since they had overheard the detailed war plans, Key and Skinner were held back by the British and were witness to the bombardment of Baltimore on September 13, 1814. Orange and red flashes of rocket fire illuminated the skies over Fort McHenry. The stillness over Chesapeake Bay was shattered by the deafening sounds of explosives. The bombardment went on all night and it was not clear as to which side would prevail in this clash of arms. At day break, as the first rays of the sun hit the fort and the fog lifted over the Bay, the American flag was still aloft Fort McHenry, fluttering in the morning breeze. This was the moving sight that inspired Francis Scott Key to compose the Star Spangled Banner.

The rockets used in the war of 1812 were a takeoff on the rockets captured by the British from Tippu Sultan of Mysore after the fourth Anglo-Mysore war of 1799. The Mysore rockets used a casing of iron unlike the plaster casings that were in common use in European rockets. The metal casing enabled the sustenance of higher pressures in the bore and increased the propulsive power of the rocket. The solid propellant was compacted gunpowder. The Mysore rockets had a range of 2 kilometers which was more than twice the range of the most advanced rockets used by European armies. Attached to the end of the iron barrel was a long bamboo pole with an affixed doubled edged sword as the payload. When launched in clusters, the sword- equipped rockets played havoc with concentrations of enemy troops.

The late Dr. Abdul Kalam, the architect of India's modern rocket programs, called Tippu Sultan the father of modern rocketry. Tippu was a technology buff and paid special attention to innovation in armament design. There were thousands of rockets in his armory. Platoons of rocket men were attached to each of his regiments. With the military edge provided by the rockets, the Sultan won a decisive victory over British forces in the Battle of Pollilur in 1780. It was the only major battle that the British lost on Indian soil during their long drawn out conquest of the Indian subcontinent, starting with the Battle of Plassey in Bengal (1757) and ending with the second Anglo-Sikh war in the Punjab (1848-49).

When Tippu Sultan fell during the fourth Anglo-Mysore war of 1799, the British sent some of the captured Mysore rockets to the Royal Laboratory at Woolwich Arsenal in England. A development team led by Colonel Congreve made a systematic study of the rockets using Newton's laws of motion. Congreve made design improvements to the rockets to make them more stable in flight. The modified Mysore rockets, renamed the Congreve rockets, were used by the British against Napoleon at the Battle of Boulogne in France in 1806. And it was the Congreve rockets that were used by the British to bombard Fort McHenry in Baltimore during the Anglo-American war of 1812.

Thus it was that the technology invented by an Indian Muslim sultan inspired the national anthem of a great nation, the United States of America, on the other side of the globe. The advances made by the rocket engineers of Tippu Sultan show that as late as the eighteenth century, technological developments in the Muslim world were not far behind those in Europe. Indeed, in some categories they were noticeably ahead. It was only in the nineteenth century that Europe acquired a decisive technological edge over Asia. We offer a few more examples to reinforce this observation.

The Mogul emperor Akbar (d 1605) introduced the matchlock rifle into the Indian armies. The 66 inch long barrel of this rifle was made from fine grained superplastic steel which was tough, fracture resistant and facilitated a finer, more uniform finish in the bore. The stronger material could sustain higher barrel pressures, which together with the long barrel, enabled the extraction of more energy from the products of combustion and imparted a higher velocity to the exiting payload. The matchlock rifle was more than a match for those made in Europe and could take down an enemy soldier at distances of more than 300 yards.

Babur's armies used a composite bow in their invasion of Delhi (1526). Made from composite layers of wood and animal fiber, the flexed, pre-stressed bows were comparable to the long English bow in their power and range but were considerably lighter, smaller and faster. The Mogul bow and arrow made the difference in the onward march of their armies through the plains of India. One must note that specialized composite materials are used in modern engineering in the construction of advanced aircraft and space hardware. For instance, I personally directed the use of a large number of advanced composites in the Hubble Space Telescope (1979-82).

Ulugh Beg (1394-1449), a Timurid prince of Central Asia, built a great astronomical observatory, called Gurkhani Zinj, at Samarkand in today's Uzbekistan. It was one of the largest and most precise observatories in the world at that time. Ulugh Beg was himself a mathematician of repute and he backed up the work at the observatory with the establishment of universities at Samarkand and Bukhara, turning them into world renowned centered of learning in the mathematical and astronomical sciences. Using observations from the observatory, he published a star catalogue called *Zij e Sultani* which was a giant leap forward upon the earlier works of Ptolemy. He measured the length of the year at 365.257 days and the tilt of the axis of rotation of the earth at 23.52 degrees. These measurements were far more precise than those made a hundred years later in Europe by Copernicus (d 1543). Ulugh Beg's accurate tables of sines and tangents were correct to eight decimal places. The work of Ulugh Beg found a resonance in the Taqi Uddin observatory of Istanbul (1574) and the string of observatories built by Raja Jai Singh of Amber (1688-1743) during the reign of Mogul emperor Mohammed Shah (d 1748). One of these observatories, called Jantar Mantar, stands in the heart of the modern metropolis of Delhi.

These examples confirm that mathematical pursuits and technological achievements did not cease with the Mongol invasions. The Ottoman, Safavid and Mogul empires that emerged after the Mongol-Tartar invasions produced a galaxy of great architects and civil engineers. The names of the Turkish master architect Mimar Sinan (d 1588) and Ustad Ahmed Lahori (1649), the architect of the Taj Mahal, stand out. The armies of these three empires excelled in metallurgy, military hardware and artillery. ↓

So, what happened?

How did the Islamic world fall behind Europe? Alternately, what explains the rise of European technology and the decay of technology in the Islamic world? Was there one overwhelming event or was it a combination of social, political, technological, religious and military factors? We will take a brief survey of Islamic history to examine the ideas, the movements, the decisive events and the personages who influenced the development of science and technology and contributed to its flourishing and its decline.

The Mu'tazalite Eruption

It was the year 760. The Abbasid Caliphate vaulted across three continents, extending from Spain to India. The Caliph al Mansur (d 775), realizing the need of a new capital for the administration of this vast empire, founded the magnificent city of Baghdad (760) on the banks of the river Tigris in Iraq. The empire brought together the peoples of Europe, Africa and Asia into a commonwealth of cultures. Baghdad became a melting pot of nations and a crucible of ideas from around the world. The resilient and self-confident Islamic civilization amalgamated these ideas and produced a composite culture that preserved and vastly expanded the intellectual horizons of humankind.

Al Mansur started a collection of classical books in Greek and Sanskrit. Under his successors, the process gathered momentum. The famed Caliph Harun al Rasheed, grandson of al Mansur, is generally credited with establishing a Bait al Hikmah (House of Wisdom) to transcribe and translate ancient texts from Greece, India, China and Persia. Under his son al Mamum, the Bait al Hikmah grew into a vast complex with separate departments for the sciences, astronomy, mathematics, logic and medicine. Here came the scholars from around the world with their books and their manuscripts, their philosophies and their sciences. The Greeks brought with them the works of Aristotle, Galen and Plato. The Indians brought the astronomical treatises of Aryabhatta. The Chinese brought the technology for making porcelain and paper. The Persians brought the technology for windmills. An observatory was constructed to measure and map the heavens and measure the movement of planets and stars. Baghdad radiated a culture of learning. Secondary libraries sprang up in major cities across the far flung empire, patronized by local governors and wealthy individuals. In later centuries, similar great centers of learning were established in Cordoba, Spain (tenth century) and Cairo, Egypt (eleventh century).

Knowledge is a gift from God. The acquisition of knowledge expands intellectual horizons and provides the propulsive power for the advancement of science and civilization. The Arabs mastered the knowledge of the Greeks and Hindus, greatly expanded it and invented new disciplines that were hitherto unknown. The accommodation of the sciences and philosophies from distant lands tested the limits of Muslim intellectual tolerance. Of all the sciences that the Islamic world were exposed to, the rational philosophy of the Greeks presented the greatest opportunity and the greatest challenge.

Muslim scholars fell in love with the rigor and precision of Greek rational thought and set out with enthusiasm to apply it to the profound questions emanating from the domains of nature, science, culture and faith. The Caliph al-Mansur was so impressed with the power and reach of reason that he adopted the rational approach as the court dogma. Those who applied the rational methods of the Greek philosophers to science, theology and culture were called the Mu'tazalites. This was the heyday for philosophy and philosophers in the Islamic world. Aristotle was their hero and his method was their guide. For eighty years, from 765 till 846, the Mu'tazalites were the darling of the Abbasid courts.

The Mu'tazalites over-extended their reach, intellectually and politically. Ancient philosophy depended heavily on a linear concept of time. Inherent to Greek logic were the assumptions of before and after, cause and effect, subject and object. As is now well understood by students of quantum mechanics and the theory of relativity, these assumptions are approximations and break down both at the sub-atomic and the galactic levels. The Mu'tazalites were unaware of these limits. When they applied their rational methods to matters of faith, they fell flat on their face. In Islam, God is transcendent, beyond time and space, and there is none like unto Him. To maintain this transcendence, the Mu'tazalites advanced the position that the Qur'an could not be co-extant with God and must therefore be construed as "created". This is a classic example of how philosophers fall into conceptual traps when they take positions on the nature of things without understanding the assumptions and the limits of their positions. For instance, can rational thought explain love? What is the reason to love? Is love eternal? The heart admits of dimensions beyond the space-time dimensions of the mind. In a larger framework, the mind is king of the created world but it cannot understand matters of the heart and is helpless before it. The Nobel Laureate Schroedinger in his book *Mind and Matter* explained it beautifully:

"Mind, for anything perception can compass, goes therefore in our spatial world more ghostly than a ghost. Invisible, intangible, it is a thing not even of outline; it is not a 'thing'. It remains without sensual confirmation and remains without it forever…. Physical science faces us with the impasse that mind per se cannot move a finger of a hand. Then the impasse meets us. The blank of the 'how' of mind's leverage on matter…is unknown", Schroedinger, *Mind and Matter*, Cambridge University Press, 1958, pp 42-43.

Faith, which is based both on reason and emotion, transcends the capabilities of the mind. Modern string theories now admit of eleven-dimensional space and the possibilities of co-extant parallel universes. The limitations of ancient philosophical thought are all too obvious.

The Mu'tazalite position that the Qur'an was "created" produced an uproar in orthodox circles. A counter-Mu'tazila movement sprang up, led by the Usuli ulema. The Mu'tazalites as well as the opposition invoked the Qur'an to justify their positions. Chief among those who opposed the Mutazalites was Imam Ahmed ibn Hanbal, after whom the Hanbali fiqh is named. The Mu'tazalites showed little political wisdom. They applied the whip to those who opposed them. Imam Ahmed was whipped and jailed many times. Faced with determined opposition, the Caliph al Mutawakkil abandoned court patronage of the Mu'tazalites (846). In turn, when the anti-Mu'tazalites had the upper hand, they persecuted the Mu'tazalites. ↓

The Aftermath of the Mu'tazalite Eruption

What is significant is that the initial challenge to the Mu'tazalites did not originate from within their own ranks but from the orthodox ulema. The triumph of the usuli schools ensured the pre-eminence of the orthodox religious elements in the spectrum of Islamic knowledge. It also made the pursuit of philosophy suspect in the minds of the masses and relegated it to the elite and the rulers. Philosophy continued but only as a side show to the primary focus of Islamic civilization on the religious sciences of fiqh (800-850 CE), hadith (800-950 CE) and tasawwuf (1100-1700 CE). In the centuries to come, those who continued to pursue philosophy and science had to look over their shoulders to guard their flank from the religious right. Philosophy and science both suffered.

The crux of the issue was a failure to understand the limits of each branch of knowledge. Philosophy is no exception of this rule. Each branch of knowledge searches for the truth but the ultimate Truth eludes certainty. God is the Truth (*Allahu Haq*). *In other words, the essence of the Truth transcends space-time*. Indeed, it transcends human comprehension. This uncertainty principle is stated in different ways by the physicists, the mathematicians, the philosophers and people of faith. The error of the Mu'tazalites was to express this uncertainty principle through logic, in space-time. The error of the usuli ulema was to reject philosophy along with the positions taken by the philosophers. It was literally the case of "throwing out the baby with the bath water".

The aftermath of the Mu'tazalite convulsions influenced the development of natural sciences in the Islamic world in a profound way. The Islamic world moved away from the speculative philosophies of the Greeks to the empirical sciences more in tune with the injunctions of the Qur'an. An explanation is in order here. Although generalizations are facile, it can nonetheless be asserted that the primary thrust of Greek philosophy is deductive. It is "top down". It starts with axioms and proceeds downwards towards deductions and conclusions. *The assumptions inherent in the axioms become the limits for the deductions and conclusions.* In this process, errors of judgment are made, as did the Mu'tazalites in their speculations about the origins of the Qur'an. By contrast, the empirical sciences are inductive. They are "bottoms up" and are based on observation, measurement, codification and extension. The Qur'an draws attention, time and again, to the many signs in nature and invites humankind to interact with and learn from these signs. *In the empirical approach, reason becomes a servant of knowledge, not its autocratic ruler.* The limits of reason are recognized and built into the edifice of knowledge as it is constructed from observations and measurements. *Thus, a scientist has his feet on the ground while reaching out to the heavens with reason. A philosopher, on the other hand, has his head in the sky but his feet may or may not touch the ground and he may be left dangling between the heavens and the earth.*

The classical Islamic civilization that emerged in the post-Mu'tazalite period was scientific-empirical. Indeed, the Muslims were arguably the originators of the empirical method. They took the pursuit of natural sciences away from the speculative philosophies of the Greeks to the experimental, practical sciences based on observation. The Muslims had learned the art of paper making from the Chinese after the Battle of Tlas (751). Paper mills sprang up in the major cities, facilitating the transcription and publication of books. Princes, noblemen and the rich vied with each other to establish libraries. The brilliance of this civilization can be gauged from the breadth and depth of its lasting contributions. For more than five hundred years (700-1258), Muslim scientists were the torch bearers of knowledge, advancing human civilization with their discoveries and inventions. It was this light that awakened Europe from its slumber in the dark ages (600-1100). The contributions of some of the eminent scientists of the Islamic Golden Age are summarily highlighted here.

Jabir Ibn-Haiyan (d 815) is known as the father of empirical chemistry. He was the first to use the process of distillation and to attempt a mathematical classification of pure elements based on their known characteristics. His work contains a detailed description of fractional distillation, solubility and volatility of compounds as well as alloying, purification and testing of metals

Al Khwarizmi (d 850), was a celebrated mathematician, astronomer and geographer. He was the inventor of algebra. His method of solving quadratic equations presaged the development of algorithms, widely used in modern software development. He was the first one to use the decimal system and to introduce the Hindu-Arabic numerals into mathematics.

Al Kindi (d 870) was a philosopher who wrote extensively on Aristotle and made noteworthy contributions not only to philosophy but also to mathematics, psychology, ethics and cosmology.

Al Razi (d 925) was an outstanding physician and chemist. He is known as the father of clinical medicine. He is best remembered for his pioneering work on smallpox, measles and other contagious diseases. His voluminous works on surgery and therapy influenced the development of medicine in Latin Europe and were required reading in European universities until the eighteenth century.

Al Battani (d 928) was a noted mathematician and empirical astronomer who influenced the works of Copernicus, Kepler and Galileo. He introduced trigonometric functions into geometry, calculated the precession of the equinoxes and the obliquity of the ecliptic. His measurements on the positions of the sun and moon were more accurate than those made by Copernicus some six centuries later.

Al-Farabi (d 950) applied Aristotelian philosophy to political science, ethics and logic. He sought to bring science, politics and ethics out of the fuzziness of symbolism into the concrete world of logic and reason. He was thus the first political scientist. The comprehensiveness of his encyclopedic works earned him the title of "the second teacher" after Aristotle and he influenced the later works of the giants among philosophers such as Ibn Sina and Maimonedes.

Al Masudi (d 956) was the first to integrate history with empirical geography. His travels took him far and wide to Egypt, Arabia, East Africa, India, Sri Lanka, Armenia, Azerbaijan and the Caspian Sea. He documented his observations of the lands he visited in his masterpiece, *Muruj adh-dhahab wa ma'adin al-jawahar (The Meadows of Gold and Mines of Gems).*

Al Buzjani (d 997) was a distinguished applied mathematician. He was the first to introduce the use of secants and cosecants in geometry. He constructed a comprehensive table of sines and tangents, made a detailed study of the inter-relationship between trigonometric functions and used this knowledge to solve difficult geometrical problems using conics. Modern trigonometry rests on a foundation built by Al Buzjani.

Ibn Sina (1037) was the most celebrated physician of the Islamic Golden Age. His masterpiece work, the Canons of Medicine, was the standard textbook in Europe until the seventeenth century. One of the most significant thinkers of the era, his influence extended to philosophy, psychology, chemistry, logic, earth sciences, astronomy and the philosophy of science.

Ibn al Haitham (d 1040) is celebrated as the father of modern optics. He was the first to recognize that light is perceived by reflection rather than emanating from the eyes, as the Greeks had assumed. He correctly formulated the laws of reflection, studied refraction, the formation of rainbows, lunar and solar eclipses and invented the *camera obscura*. His work influenced Roger Bacon (1292) of England and the celebrated German astronomer Johannes Kepler (d 1630).

Al Baruni (d 1052) was a celebrated historian whose encyclopedic work on the sciences, civilization and culture of India set a benchmark for empirical anthropological documentation. He was also a mathematician of the first rank as well as a noted astronomer, natural philosopher, geographer and geologist.

Omar Khayyam (d 1131), poet, mathematician and astronomer, left his mark on the sciences with his contributions to the Jalali calendar introduced by the Seljuq Sultan Malik Shah. This calendar was more precise than the Julian calendar used in the modern world. Omar Khayyam developed a method of extracting roots of whole numbers and influenced the development of irrational numbers by European mathematicians. Through the translations of his *Rubayiat*, he is celebrated as a poet the world over.

Al Idrisi (d 1165) was a geographer and historian who served at the court of Roger II of Sicily. He compiled a map of the known world using earlier sources as well as his own observations through his travels in the Magreb (North-west Africa) and West Asia. The map was extraordinary for its times and showed Western Europe, the Mediterranean world and West Asia in great detail. In his book, *Kitāb nuzhat al-mushtāq fī ikhtirāq al-āfāq* ("The Pleasure Excursion of One Who Is Eager to Traverse the Regions of the World"), al Idrisi describes contacts between the Arabs and certain islands near the West Indies of America. Historians have used al Idrisi's observations to assert the African and Muslim discovery of America before Columbus.

Ibn Rushd (d 1198) is generally considered the greatest rational philosopher after Aristotle. His three volume commentary on the works of the Greek Master profoundly influenced the development of rational thought in the Latin West. Ibn Rushd also wrote extensively on jurisprudence, psychology, astronomy, physics and music theory.

Al Jazari (d 1206) was the most prolific inventor of his age. He was an outstanding engineer and a mechanical genius. More than 100 inventions are ascribed to him, including the cam shaft, rotary to linear motion converters, segmented gears, chain pumps, water pumps, clocks and mechanical robots. He was arguably the father of robotics. ↓

The Asharite Response

The intellectual storms created by the Mu'tazalite and anti-Mu'tazalite movements continued to rage long after the eighth century. The Islamic world had come face to face with Greek rationalism and was trying to reconcile its belief system with reason. Was there an interface between reason and faith? If there was one, where was it? The major intellectual figures of the Islamic Golden Age grappled with this question and advanced their own views and their own theories.

Among the most influential of the usuli ulema who tried a reconciliation of reason with faith was the Shafi' scholar Abul Hasan al Ash'ari (d 936). To maintain the transcendence of God and preserve His power over all decisions, Al Ash'ari advanced the thesis that time was discrete and was built up of small increments (atoms). At each increment of time, the Will of God intervenes and determines the outcome of an event. Thus, *in the Asharite cosmology, a natural law which appears to follow the logic of cause and effect gets broken up into an infinite series of occasions for the intervention of the Will of God.* Those who accepted the philosophy of al Ash'ari were called Asharites. The Asharite ideas found wide acceptance in the Islamic world and influenced some of the major thinkers of Islamic history including Al Gazzali and Allama Iqbal.

Al Ash'ari's thesis was a major step towards a reconciliation of faith and reason. Al Ash'ari rejected the Mu'tazalite position that the Qur'an was "created". He explained that the divine attributes of seeing, hearing and action are different from those of human beings and must not be understood in anthropological terms.

However, in advancing his own "atomistic" theory of time, Al Ash'ari left himself open to a critique from the philosophers and scientists. What is time? Is it linear? Is it discrete? Is it warped? Is it even "real"? The limits of reason are the limits of human understanding of time. *The Qur'an offers profound insights into the nature of time to guide humankind in its quest for the Truth. The passage of time, absolute time, perceived time, time as a moment, time as a day and as a mirage are all clarified in different contexts in the Qur'an.* The definition of a natural phenomenon must therefore state, *a priori*, its assumptions of time within which the phenomenon are defined. Otherwise, observations, theories and deductions that are derived in one time frame become speculative when applied to a different time frame. Al Ash'ari won the debate against the Mu'tazalites of the day. However, his assumptions are insufficient to accommodate modern theories of quantum physics. The search for a satisfactory definition of the interface between reason and faith is perpetual and must continue.

The Approach of Ibn Sina and the Scientists

Ibn Sina was one of the most celebrated scientists of the Islamic Golden Age. His approach to the question of cause and effect in nature was fundamentally different from that al Ash'ari. To preserve the overarching authority of Divine Will in nature, Al Ash'ari conceived of time as moving in discrete, small increments (atoms). Ibn Sina, on the other hand, tackled the more fundamental issues of "change" and the "agent of change". He constructed a hierarchy of causers of change and distinguished between the "necessary" and the "contingent". God is "necessary", he maintained, whereas the created world is "contingent". In the cosmology of Ibn Sina, the metaphysical structures of necessity and contingency were different. The necessary is "the source of its own being without borrowed existence. It is what always exists". By contrast, "the contingent being is 'false in itself' and 'true due to something else other than itself….. It is actualized by an external cause other than itself." Thus the theories of Ibn Sina stay close to the guidance provided by the Qur'an. However, his esoteric arguments of the "necessary" and the "contingent" were too complex for the layman and his works remained unknown except among the scholars and the elite.

Al Gazzali's Tahafut al Falasafa (Repudiation of the Philosophers)

Abu Hamid al-Gazzali (d 1111) was one of the most influential theologians, jurists and skeptical philosophers in Islamic history. Born into a Persian-Arab family in Tus in Northeastern Iran, Al-Gazzali received his early training in Qur'an, fiqh and tasawwuf in the local religious schools and then studied under a well-known scholar, al-Juwayni of Nishapur. The erudition, brilliance and intellectual acuity of the young Al-Gazzali attracted the attention of Nizam ul Mulk, the grand vizier of the reigning Seljuks, who conferred upon him the title of "*hujjaatul Islam*" (evidence of Islam) and appointed him a professor at the Nizamiya College in Baghdad. His lectures on jurisprudence and tasawwuf attracted a wide following and his fame spread far and wide.

After teaching at the College for four years, Al Gazzali went through a profound internal crisis. Outward ritualistic observances of religion and esoteric philosophical discourses brought him no inner peace. He quit his prestigious professorship and embarked on a journal to Damascus, Jerusalem and onto Mecca and Madina for hajj. His introspections during this period brought him the conviction that true faith resided in the heart and it was only through a cleansing of the heart and constant remembrance of God that man ascends to Divine presence. Al Gazzali returned to Nishapur (1098) where he founded and taught at a Zawiya, a college structured on Sufi teachings. In 1106 he returned to the Nizamiya College and continued to teach there until his death.

Al Gazzali lived in a period of great political turmoil. The Islamic world was divided between the Fatimids in Cairo and the Abbasids in Baghdad. The Sunni Seljuqs backed the Abbasids and were engaged in a military struggle with the Shia Buyids of Iraq for control of Baghdad. The Crusaders, taking advantage of the Fatimid-Abbasid rivalries, were successful in capturing Jerusalem in 1099. The assassins, a band of disgruntled Fatimids, were active throughout the Islamic world, causing havoc with their targeted killings of Sunni leadership. Nizamul ul Mulk himself fell to an assassin's dagger in 1092. On the intellectual plane, the turbulence generated by the injection of Greek philosophy continued to roil theological debates. It had been four hundred years since the Mu'tazalite movement had first enjoyed and then lost the patronage of the Abbasid courts in Baghdad. Through these centuries, the intellectual genius of Muslim scholars had struggled to accommodate the challenge of Greek ideas. The work of Al Ash'ari (d 936) had brought a degree of calm to this intellectual landscape but the undercurrents of a perceived disharmony between faith and reason persisted.

Al Gazzali injected himself headlong into the Fatimid-Sunni and philosophy-theology debates. His dialectic reflects the political and intellectual turmoil of the age. He argued eloquently against the esoteric doctrines of the Fatimids as well as the deductive approach of the philosophers. In his treatise *Tahaffuz al Falasafa* (Repudiation of the Philosophers), he contended that the metaphysical arguments of the philosophers did not meet the test of reason. Basing his powerful dialectic on the earlier works of al Ash'ari, Al Gazzali argued that there was no cause and effect in nature, and that all natural events happen by the Will of God.

"The connection between what is habitually believed to be a cause and what is habitually believed to be an effect is not necessary….. For any two things, it is not necessary that the existence or the nonexistence of the one follows necessarily from the existence or the nonexistence of the other. Their connection is due to the *taqdir* of God, who creates them side by side, not to its being necessary by itself."

Al Gazzali supported his argument by offering the combustion of cotton as an example:

"We say that the efficient cause of the combustion through the creation of blackness in the cotton and through causing the separation of its parts and turning it into coal or ashes is God—either through the mediation of the angels or without mediation".

In modern language, Al Gazzali's position can be stated as follows: The laws of nature are not deterministic. Cause and effect are not necessary consequences of each other; they exist "side by side". The outcome of a natural phenomenon is a moment of God's grace. ↓

The Legacy of Al Gazzali

Al Gazzali's dialectic on philosophy had a global impact both on the Islamic as well as Western civilizations. Although Al Gazzali's thrust was against the arguments of the philosophers rather than philosophy itself, his encyclopedic works had a chilling effect on the pursuit of philosophy in the Islamic world. In essence, it eliminated reason from the realm of natural phenomenon.

The Riposte of Ibn Rushd

As interest in philosophy waned, the Spaniard Ibn Rushd (d 1198) took up the defense of philosophy. Considered a giant among philosophers, Ibn Rushd wrote extensive commentaries on the works of Aristotle. He took issue with Al Gazzali's position that there was no cause and effect in nature. In his *Tahaffut at Tahaffut* (Repudiation of the Repudiation) he argued that reason was a valid tool for understanding both nature and revelation. Whereas Al Gazzali had questioned the validity of cause and effect in nature, arguing that phenomenon happen only by the will of God, *Ibn Rushd argued that natural phenomenon followed laws ordained by God. Thus the sway of Divine Will over all affairs is preserved both through the natural laws and their outcomes.* However, the Islamic world chose the mysticism of Al Gazzali over the rationalism of Ibn Rushd. Reason was marginalized, whereas mysticism thrived.

As Spain fell to the Christian Conquistadores (1086-1248), Latin translations of the works of Ibn Rushd and other Muslim philosophers became available in Europe and were a driving force for the rise of the scholastic tradition in Christendom. Universities sprang up all over Europe. Those at Bologna (1088), Paris (1150), Oxford (1096), Cambridge (1209). Rome (1303), Florence (1321), Prague (1348), Vienna (1365), Venice (1470), and Valencia (1499) are well known. European scholasticism, having arrived at the same point in philosophy that Muslim philosophy had arrived at three hundred years earlier resolved the apparent tensions between philosophy and religion in a fundamentally different way. One of the principal figures in this tradition was Thomas Aquinas. *Whereas Muslim philosophers had struggled to maintain the omnipotence of God in nature and human affairs by speculating on the nature of time and advancing the idea of "the necessary" and "the contingent", the European philosophers separated nature and theology into separate compartments. Nature, they concluded, was within the domain of reason; matters of theology were beyond its reach. And thus the separation into sacred and secular.*

The Interaction of Faith with Reason in Europe and the Islamic World, a Contrast in Outcomes

To recap, here is a summary of the galactic battles between faith and reason in Islam and Christianity: The first to attempt a reconciliation of faith and reason were the Mu'tazalites. They overextended their reach by applying reason to the divine realm without a sufficient grasp of the limits of reason. To preserve the transcendence of God they speculated that the Word of God was "created". In other words, they tried to contain the Word of God in the confines of reason and were summarily rejected by Islamic orthodoxy. The Asharites advanced an "atomistic" theory of time. This view did gain wide traction and became a part of Islamic thought. The Muslim scientists used a different approach by suggesting that the domain of the Divine was "necessary" whereas that of nature was "contingent". This view was too esoteric for main street Islam to absorb. Al Gazzali stood on the shoulders of the Asharites and the scientists but in his attempt to repudiate the philosophers, he went too far and banished reason from nature. Ibn Rushd tried to contain the damage done by Al Gazzali but the Islamic world chose Al Gazzali over Ibn Rushd. The Latin West accommodated reason with faith but they paid a heavy price for this accommodation; they banished reason from faith and made the natural sciences secular.

The Simultaneous Mongol Invasions and the Crusades

The Mongol invasions of the thirteenth century (1219-1257) devastated much of the eastern Islamic world. The great cities of Samarkand, Bokhara, Merv, Nishapur, Ghazna, Esfahan, Tabriz and Baghdad were destroyed. A vast swath of territories extending from the Amu Darya (in Central Asia) to the hills of Jerusalem was decimated. The nomadic Mongols had no use for agriculture. Dams were leveled and canals filled in. Libraries were burned. Men of learning were slaughtered. In short, the curtain fell on the classic Islamic civilization that had nurtured science and philosophy for five hundred years.

While the Mongols ravaged the eastern provinces of the Islamic world, the Crusades were active in the West. When the Caliphate of Cordoba disintegrated in 1031 and al Andalus broke up into warring principalities, it was a signal for the Christian powers to enter the fray. Toledo, the ancient Visigoth capital, fell in 1086 and Lisbon in Portugal in 1147. After the disastrous defeat of Muslim armies at the battle of Las Novas de Tolosa (1212), the Conquistadores rapidly overran most of Spain. Córdoba, the seat of the Spanish Caliphate fell in 1236, followed by Seville in 1248. Only the Southern tip of Spain around Granada and the hills of Pujara held out until 1492.

Thus, within a span of a generation between 1219 and 1258, more than half of the Islamic world was either destroyed or occupied. The areas ravaged by the Mongols included what is today Uzbekistan Turkmenistan, Azerbaijan, Afghanistan, Pakistan up to the river Indus, Iran, Iraq, Eastern Anatolia and Syria. In the West, the province of Spain was lost. The major centers of Islamic learning were either destroyed or came under the control of their adversaries.

The simultaneous loss of the prosperous cities of Persia and Spain was a blow from which the Islamic civilization never recovered. With the rulers gone, the pursuit of philosophy and science, which depended heavily on patronage from the top, suffered a mortal blow. It was the end of the Golden Age of science in Islam.

The Islam that emerged after the Mongol-Crusader onslaughts was a spiritual Islam, less empirical and exoteric and more esoteric and spiritual. These destruction tested the metal of Islamic civilization. In its darkest hour, the inner spirituality of Islam rose up to the challenge. Islam renewed itself through tasawwuf and was successful in converting the Mongols. Astronomy, architecture and artisanship won the patronage of the new rulers and continued to flourish. However, the natural sciences were neglected. The emphasis of Islamic civilization shifted decidedly towards the sciences of the soul. Whereas the archetype of the Golden Age were philosophers and scientists like al Razi and Ibn Sina, the archetypes of the Sufi age were Shaikh Abdel Qader Jeelani of Baghdad, Shaikh Shadhuli of Cairo, Ibn al Arabi of Spain, Mevlana Rumi of Anatolia and Shah Naqshband of Samarqand. It was this Sufic Islam, syncretic in its tendencies, open and inclusive towards other faiths that spread to the India-Pakistan subcontinent, Indonesia, Malaysia, sub Saharan Africa and Eastern Europe.

Out of the political turmoil of the Mongol-Tartar invasions, there emerged three strong land empires in Asia- the Ottomans who straddled the Eastern Mediterranean and North Africa, the Safavids of Persia and the Moguls of India. All three of these empires patronized art, architecture, astronomy and artisanship but neglected the natural sciences. The Ottomans, for instance were strong in metallurgy and cannon manufacture. However, the design and manufacture of guns and engines of war was more driven by superb artisanship than a basic understanding of the physics of armaments. This trend continued for four centuries. For instance, the Mysore rockets that were used during the Anglo-Mysore wars (1770-1799) had twice the range of anything used in Europe at the time. However, there is no indication that the master artisans who produced them had a deep understanding of Newton's laws of physics well known to European scientists of the era.

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Neglect of science, the printing press and naval technology

As was observed in the previous section, although art, architecture, literature and poetry flourished and artisanship and craftsmanship were valued, the post-Mongol period was characterized by a marked decrease in the pursuit of the basic sciences.   The era produced architects like Mimar Sinan and Ahmed Lahori, poets like Rumi, Hafiz and Amir Khusroe, astronomers like Ibn al Shatir but no scientific figures of the stature of Ibn Sina. So, when Europe embarked on a scientific and technological revolution (1600-1800), the Islamic world was found napping and finally succumbed to the European military onslaught.

Most noticeable was the delay in the introduction of the printing press which was introduced into Europe in 1439 and spread throughout Europe by the end of the fifteenth century. In Italy alone, there were no less than 77 printing presses in the year 1500. The printing press made possible the spread of knowledge. It was one of the main engines for the Renaissance which produced the likes of Michelangelo and Leonardo da Vinci. It was only in 1728 that the printing press was introduced into the Ottoman Empire. It was introduced into Mughal India much later, at the beginning of the nineteenth century. In both cases, what held back the introduction of this technology was the opposition of the *ulema* who held that the Word of God would be defiled by contact with wooden presses. Indeed, the ulema increasingly became hostile to the basic sciences, which they did not understand. A case in point is the destruction of the Istanbul observatory in 1577 at the behest of the religious establishment, who suspected that the Ottoman defeat in the Battle of Lepanto (1571) was somehow related to the ungodly pursuits of the astronomers.

Equally disastrous was a neglect of naval technology. After the Battle of Lepanto (1571), there was a steady and inexorable decay in the naval prowess of the Muslim empires. By the year 1700, the Ottoman Empire spent as much on its navy as it did on the royal kitchens. The result was that the Muslims who had controlled the trade between Asia and the Mediterranean worlds surrendered it to Europe. Control of the seas also meant that the balance of global power shifted inexorably in favor of the West. Europe went on to discover America and circumnavigate the horn of Africa bypassing the trade routes through the Middle East. Europe thrived while Muslim lands sank into poverty.

Concurrent with the loss of the technological edge and political power, there was a regression in intellectual activity as well. *While new universities sprang up all over Europe, embracing the pursuit of science and philosophy with vigor, the Muslim world was content to recycle what it had learned five hundred years earlier.* There was no innovation in education. The Madrasas and Zawiyas of the Muslims encouraged learning by rote while the European universities encouraged critical thinking and scientific education.

So, when Europe entered the early modern period based on scientific discoveries and technological innovation and produced Kepler, Galileo, Boyle, Bacon, Newton and Pascal, the Islamic world just could not compete. For almost three hundred years Europe enjoyed a near monopoly in scientific discourse and scientific advancements. It was only in the latter part of the nineteenth century that scientific knowledge was diffused throughout Asia, starting with Japan and later spreading through China and India.

The raging controversies….. Extremism, Salafism, Shia, Sunni, Sectarianism

While religious schisms were not unknown in Europe and the Protestant-Catholic rivalries often erupted into armed conflict, the pursuit of scientific endeavor managed to transcend these divisions. Science had become a secular enterprise open to all shades of religious opinion. The printing press made possible the widest dissemination of knowledge. More than a million books were printed in Europe in the seventeenth century. There were respected scientists among the Protestants as there were among the Catholics and they built an edifice of science as a cooperative enterprise.

By contrast, the post-Timurid period (1400-1700) in the Islamic world was characterized by sharpened conflicts between Shias and Sunnis, Sufis and Salafis. The Safavids in Persia were Shia and they were engaged in continual conflicts with the Sunni Ottomans. Iran acted as a wedge between the Ottomans and the Moguls of India, preventing any effective military coordination between the two Sunni powers. For example, the Ottoman Sultan Suleyman II asked the Mogul emperor Aurangzeb for assistance against the Grand Christian Alliance during the wars of 1683-1699. Aurangzeb could not and did not send a relief column to the Ottomans because he was occupied in a prolonged conflict with the Shia kingdoms of the Deccan in southern Indian. A second example is the appeal of Tippu Sultan of Mysore to Amir Zaman Shah of Afghanistan in 1798 for military help against the British. Zaman Shah was disposed to help but was prevented from doing so because of a British inspired Shia uprising in Herat in Western Afghanistan.

A new schism arose in the Islamic world in the mid seventeenth century which had a profound impact on the development of science and civilization in Islam. The post Mongol-Tartar era was dominated by Sufic Islam. It was inherently syncretic, open to absorbing the cultures of the lands into which it made inroads. Thus the Hindus of India and the Buddhists of Indonesia found it easier to walk into the fold of Sufi Islam. This syncretic Islam produced great rulers like Akbar (d 1605) of Mogul India. However the very success of Sufi Islam generated a counter reaction, starting with India. Aurangzeb (d 1707) ascended the throne of Mogul India after Shah Jehan and embarked on dismantling the inclusive syncretic culture built by his great-grand father Akbar. Akbar had included the Hindus as people of the book, marrying Hindu princesses and abolishing discriminatory taxes against them. Aurangzeb reinstated the jizya and replaced the Sufi south Asian culture, which he viewed as deviationist, with a juridical Islam codified in *Futuhat e Alamgiri*. The Hindus and the Sikhs rebelled, starting the long process of political disintegration. The political decay was reflected in the arts, architecture, artisanship, science and culture.

A harsher, uncompromising version of Islam was introduced by Abdel Wahab of Arabia (d 1792). Proclaiming that all practices which were not in strict conformity with the practices of the earliest Muslims were *bida'* (innovation), Abdel Wahab waged a relentless struggle against the Bedouins of Arabia, forcing them into conformance with his views. The stern creed of Abdel Wahab was adopted as the official dogma by Saudi Arabia. With the discovery of oil in the Middle East (1908), and the enormous wealth that accrued with it, the reach of Wahhabi ideas extended to the entire globe. The word "Wahhabism" carried a connotation of extreme rigidity in religious matters. This rigidity extended to science and culture as well. For instance, until recently, the major universities in Arabia were opposed to photography and videos. Only recently has the Saudi religious establishment made an about-face, and now the students in Saudi universities openly carry mobile phones with video features.

The raging controversies over sectarian differences drained the intellectual resources of the global Islamic community. Bogged down over questions of what was permissible and what was not, science and philosophy were marooned. The controversies persist to this day.

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The Colonial Period

Europe used its technological and scientific advantage to colonize much of Asia and Africa. India was the first great Asian civilization to fall to the West (1757-1947). By the end of the nineteenth century most of the Islamic world with the exception of the core Ottoman Empire and the Iranian heartland had been colonized. There was resistance to the European onslaught, for instance, from Tippu Sultan of Mysore, who built a navy to patrol the Arabian Sea and rockets to defend his kingdom. But these efforts were too little, too late. By the end of the eighteenth century, the resistance had ended and the scientific and technological sway of the west was unchallenged both on land and on sea.

The European powers dismantled the educational infrastructure of the colonized lands which had grown over many centuries, thereby injecting a discontinuity in the intellectual development of the colonized people. The zawiyas and madrassas which had provided the educational foundation of the Muslim world were either marginalized or disappeared. Their place was taken up by government schools run by the colonial authorities whose purpose was to educate the native population to man the lower echelons of administrative bureaucracies in the colonized lands. Science and technology, which at best were flickering in the old institutions, died out. The science and technology gap between a colonizing Europe and a colonized Afro-Asia increased.

A Challenging Future

It was only in the latter half of the nineteenth century that the Islamic world woke up to the need to learn the natural sciences from the west. In India, the Aligarh Muslim University was founded by Syed Ahmed Khan (d 1898). It was patterned after European schools and its intent was to educate Indian Muslims in the sciences, arts and technologies of the west. In the Ottoman Empire, a determined effort was made to cultivate science and technology through the Tanzeemat, and technical universities were established in Istanbul and other major cities. Some of the gifted students from these universities went on to study in Europe and acquire more advanced training in science and technology. The trend continues to this day; the few notable Muslim scientists and engineers have been primarily products of American and European universities.

However, in the global picture, the Islamic world continues to lag behind the west in science and technology. Not a single institution of higher learning in Muslim countries is listed among the top 100 science institutions of the world. Of the nine hundred Nobel Laureates since the Nobel Prize was established, only nine have been Muslim. Of these nine, six Noble prizes were awarded for promoting peace. There have been only three Muslim Noble Laureates in science, and all of them were educated and worked at universities in America or Europe. Less than one percent of the names that appear in the database of the United States Patents and Trademarks Office are Muslim and a similar trend is observable in the respectable scientific journals of the world. Literacy in Muslim lands is among the lowest in the world. For instance, only 47 percent of women in Kashmir are literate which means more than half of them cannot even read and write their own name. What is more alarming is that the education gap between Muslim countries and the emerging economies such as those of China and India in increasing. War, physical dislocation, extremism and neglect have all taken their toll. Meanwhile, the Muslims continue to be bogged down with arguments over *haram, bida', shirk and kufr, hijab*, beards and *halal* meat. Education is valued only for its monetary benefits. Extremism has taken its toll. In Pakistan, women and girls are attacked for going to school. Religion has been hijacked by professional mullahs. The term *a'lim* is reserved for one who has studied in a madrasa. Knowledge has been compartmentalized into religious and secular. Scholarship in the sciences is not valued. The ignorant mullahs look down upon the natural sciences as secular and debasing.

Is renewal possible?

A revival of natural sciences in the Islamic world requires, at the minimum, the following:

- o Develop a framework to encourage the pursuit of the natural sciences in conformance with the Qur'an. This is within the reach of the current generation of intellectuals. An attempt in this direction has been made by this writer and it has been published in the Encyclopedia of Islamic History, historyofislam.com (http://www.historyofislam.com). Nature, history and the soul offer "Signs" from God. The Qur'an urges humankind, time and again, to observe, ponder over and learn from these Signs. This profound guidance offers the possibility of reconciliation between faith and reason. Accommodate the natural sciences (science and technology), historical sciences (sociology and history) and studies of the soul (tasawwuf) into basic Islamic education. As the Qur'an states: "Soon shall We show them Our Signs, on the horizon as well as within their own Selves, until they have certainty that it is the Truth".

- o Encourage a culture of reason and rational discourse. Use technology to diffuse this culture in society.
- o Encourage science education in primary and secondary schools.
- o Establish Centers of Excellence wherein scholars and seekers of knowledge meet and learn.
- o Provide societal recognition and financial support for those who pursue science and technology.
- o Train the religious establishment, the *a'lims* and the *mullahs*, in the basics of science and technology.
- o Establish peace and stability in the land.

The current bleak situation is a challenge and an opportunity for Islamic civilization. Islam is a great civilization. It has faced many challenges in its long history and has renewed itself time and again to emerge stronger and more resilient. Our hope is that it will once again rise up to the current challenge, renew itself and will march forward with the light of knowledge.

"Indeed, with every difficulty there is relief". (The Qur'an, 94:6)

Comments are closed.