The Rise and Decline of Science in Islamic Civilization

Ayub K. Ommaya, M.D.,
Bethesda, Maryland

DOI: http://dx.doi.org/10.5915/22-1-13526

Abstract

The rise of science in the Islamic civilization was the direct consequence of the unique transformation of human minds by Islam. As Islam spread to other nations, Muslims were exposed to other societies and their civilizations. There was a remarkable in-gathering and synthesis of human knowledge. Islamic scientists dominated the scene for several centuries but gradually science started to suffer a decline along with the decline of the political eminence of the Muslim state. The factors both extrinsic and intrinsic for this decline are discussed.

Key words: *Islamic civilization, Muslim scientists, Islamic scientific contributions, Mughal Empire, The Ottoman Empire, Mongol invasion.*

For the believer, Islam is the last in a series of revelations of the eternal truth in the tradition of Abraham (Ibrahim) after Judaism and Christianity. This third and final manifestation of the Divine Logos in the present cycle of human history is in a sense a return to the original unity of the religion of Abraham. Judaism emphasizes the law or exoteric aspect (awe of God) and Christianity, the Way, or esoteric aspect (love of God) of this tradition. Islam integrates the Abrahamic tradition by containing a law (Sharī'ah) and a way (ṭarīqah) and emphasizes knowledge of God. It should be noted this is only a matter of emphasis because each religion contains all of these three fundamental aspects of the relation between man and God. In Islam, however, all human actions including those which contribute to scientific advances, require conscious awareness of their relation to God.

For the non-believer it is perhaps not easy to understand the evolution of science in Islam without some knowledge of the context in which it developed, i.e., the world civilization created by the religion of Islam. Powered by an overwhelming release of energy, Islamic culture exploded as it were, onto the pages of human history starting in the fortieth year of the life of Prophet Muhammad (PBUH), an illiterate but respected trader in Arabia who received the divine revelation at the turn of the 7th Century of the Christian Era.[1]

The form in which the Islamic sciences were produced was not a matter of mere "chance and necessity," to use the phrase of Jacques Monod.[2] It was the direct consequence of the unique transformation of human minds by Islam and secondarily, the social conditions resulting from the radical change in a tribal culture interacting with more advanced societies. The cultural changes which followed developed rapidly, first in the heartlands of the Middle East and adjacent nations, but ultimately spreading the Islamic venture into China and Indonesia in the East and to Europe in the West. Ac-

From the Department of Neurosurgery
George Washington University
Washington, D.C.
and the
Foundation for Fundamental and Applied Neuroscience
Bethesda, MD

Presented: Al-Razi Memorial Lecture
21st Annual Convention
Islamic Medical Association of North America
Anaheim, California
July, 1988

Reprint Requests: Dr. A. K. Ommaya
8006 Gluebrook Road
Bethesda, MD 20814

companying these dramatic changes in the social and ethical codes of a large variety of nationalities there was also a remarkable in-gathering and synthesis of existing human knowledge. Islamic translators brought together what was known about science and learning in all its forms, from Egyptian, Babylonian, Indian, Greek, Iranian, Sabaen and Chinese sources. This was an immense encyclopedic effort which laid the foundations for new developments in experimental method, theory and technological applications. What should be emphasized, however, is that these contributions to science in the sense of that word as we know it today, were part and parcel of the essential metaphysical doctrine of the Muslim (one who believes in Islam) as a being created to reflect the Divine. Thus science was considered a part of the work of such a being which had to be integrated into his or her daily life, as well as into the study of the source of Islamic revelation, Al Qur'ān. The style of Islamic civilization and the minds of Muslims were joined by a particular spirituality "barakah" emanating directly from this Holy Book which emphasized the necessity for reflection on the laws of nature, e.g.:

Allāh says:

"Verily, in the creation of the Heavens and of the Earth, and in the alternation of the night and the day there are signs for men of understanding. They who standing, sitting or reclining bear Allāh in mind and reflect on the creation of the Heavens and of the Earth, saying: 'O our lord! Thou hast not created this in vain . . . '"[3]

As pointed out by Abdus Salam, Nobel laureate in physics, there are "750 verses of the Qur'ān (almost one eighth of the Book) which exhort believers to study nature, to reflect, to make the best use of the reason in their search for the ultimate, and to make the acquiring of knowledge and scientific comprehension part of the community's life." Similarly, in the sayings of Prophet Muḥammad (PBUH) we find similar emphasis on the need to enhance knowledge and its linkage to spirituality emphasizing that men of knowledge are the true inheritors of the prophet.[4]

The message of Islam is most of all concerned with what a human being is, or more precisely put, how a human can fully become what he or she really is in their primordial nature "fiṭrah", i.e., a theomorphic being created to reflect the Divine in all its beauty and majesty. This metaphysical doctrine is the supreme "science of the sacred" contained within the inner dimensions of the Qur'ān and has two aspects: the fundamental Unity of the Principle "Al-tawḥīd" and the interrelatedness of all the diversity in nature brought into being by the creative act (the "kun" of the Qur'ānic statement, "Be (kun) and it is").

"Verily, when He intends a thing, His command is "Be", and it is."[5]

The other aspect is the human complement of this principle as in the doctrine of the universal human "al-insān al-kāmil" in whom the true fullness of the human state is realized and through whom multiplicity and the apparent diversity of nature returns to unity.[6-8] This unifying perspective of Islam requires that whatever forms of knowledge be developed they must be interpreted in such a way as to reflect the true structure of Reality which is God. Another way to put this would be to say that, because Islam aims at a total harmony of belief and action, intellectual compartmentalization of science, art and religion, and the creation of subjective-objective dichotomies in our understanding of who we are, our place in nature and how God fits into our conception of reality should be viewed as inadequacies of knowledge, and as such, these conceptualizations are stumbling blocks to be overcome in the evolution of universal human beings.

Given this perspective, it now becomes possible to pose the main issue of this paper. What are the factors which led to the paradox of an Islamic civilizaion, the civilization which led the world in science for almost 400 years and then entered a long period of scientific and technological decline, after which it has become seriously depleted of the very power it once so brilliantly shaped and used? This decline shows no sign of being overcome in spite of the continuing and growing strength of exoteric Islam. How is it that what was once a unified way of believing and acting in this world, that produced world class leaders in science and set the stage for the Renaissance, could fall so low? Why is the world of Islam so weak in science and technology today?

The Rise of Science in Islamic Civilization

Having placed our subject securely in the context of Islam, I will now briefly review some of the facts about Muslim contributions to science. As heirs to the intellectual heritage of all the major civilizations of that time (excepting that of China and the Far East) Islam was able to create the first science of a truly international nature in human history. This was the direct consequence of the universal nature of Islam, as well as the geographical spread of Islamic culture. The primary sources were of Greek, Indian and Persian origin with Chinese scientific works being integrated after the Mongol invasion. The actual process by which these source materials were translated from such diverse languages as Greek, Syriac, Sanskrit and Pahlavi into Arabic is probably one of the most unique examples of accelerated cultural transmission. In both quantitative and qualitative terms this effort surpassed all similar efforts, e.g., the translation of the Buddist texts into

Chinese and of Arabic works into Latin in medieval Europe.[6,8]

How significantly did Islamic culture and the work of Muslims affect the course of scientific history? An approximate measure of this contribution is given by George Sarton in his three volume history of science.[9]

Sarton divides his account of the highest achievement in science into "ages", each "age" lasting about 50 years and with one central person associated with the "age." Thus 500-450 B.C. is the Age of Plato, followed by the Ages of Aristotle, Euclid, Archimedes and so forth. From 750 A.D. (c.e.) to 1100 A.D. (c.e.) we find an unbroken sucession of Islamic scientists: the Ages of Jābir, Khawarizmī, al-Razī, Masūdī, 'Abu'l-Wafā, al-Bīrūnī and 'Umar al Khayyām. Strikingly, for 350 years there are no names outside the world of Islam. Arabs, Turks, Afghans, Persians and converts from Judaism and Christianity dominated the world stage of science in the fields of chemistry, mathematics, medicine, geography, physics and astronomy. According to Sarton it was only after 1100 A.D. (c.e.) that Western names began to appear, but even then and for 250 years more they share the ages of scientific honour with Muslims like Ibn Rushd, Nāṣir-ud-din al-Tūsī, and Ibn al-Nafīs.

An important aspect of the Islamic Age of scientific prominence was the reverence in which learning and science were held. This patronage of science by the dominant elites was of course the major and perhaps the only source of funding in the absence of institutional arrangements. Quite logically when the socio-political domination of the world by Islam began to fade in the Middle Ages, patronage also began to dissipate.

In this brief acount, I cannot do justice to all scientific achievements of Islamic science and accordingly will mention only a few centered around what Abdus Salam has called "The Golden Age of Science in Islam," which laid the foundations for the experimental method.[4] This period straddles the year 1000 A.D. (c.e.) between Ibn Sīnā (Avicenna), the last of the medievalists, and his contemporaries, the first of the modernists, Ibn al-Haytham and al-Bīrūnī.

Ibn al-Haytham, known as Alhazen in the West, was one of the greatest physicists of all time and an experimentalist of the first rank in the science of optics. When he claimed that "a ray of light, in passing through a medium, takes the path which is easier and quicker," he anticipated Fermat's Principle of Least Time by many centuries. He described the law of inertia, later to become Newton's first Law of Motion. Refraction was described in mechanical terms by considering the movement of "particles of light" as they passed through the surface of separation between two media, in accordance with the rectangle law of force — an approach later rediscovered and elaborated by Newton. Roger Bacon's Opus Majus Part V is essentially a copy of Ibn al-Haytham's Optics. It is not surprising therefore that we hear of Bacon's admonition to his own contemporaries in the West that he "never wearied of declaring that a knowledge of Arabic and of Arabic science was the only way to true knowledge."[4]

Al-Bīrūnī (973-1048 A.D. [c.e.]) was an empirical scientist like Ibn al-Haytham, who worked in Afghanistan. He anticipated Galileo by six centuries in his discovery of the so-called Galilean invariance of the laws of nature — perhaps the most liberating statement in science, "that the same laws of physics apply here on earth as they do the stars and planets in the heavens."[4]

Unquestionably, Western science is a Greco-Islamic legacy. Those Western scholars who allege that Islamic science simply followed Greek theoretical traditions blindly without adding to the scientific method are simply ignorant of the historical evidence to the contrary. Islamic scientists demonstrated what we know now to be the only way to do intense scientific work. First learn and build your knowledge on what is available ("reading the literature"), then examine your doubts about what you have learned ("developing hypotheses"), and finally, the critical step, make new observations and experiments of your own. This critical step in the history of science came early in Islamic science and its clearest exponents were Ibn al-Haytham and al-Bīrūnī.[4]

Here is what al-Bīrūnī wrote concerning Aristotle:

"The trouble with most people is their extravagance in respect of Aristotle's opinions: they believe that there is no possibility of mistakes in his views, though they know that he was only theorizing to the best of his capacity and never claimed to be God's protected and immune from mistakes."[4]

And here is how al-Bīrūnī denounced medieval supersition:

"People say that on the sixth of January there is an hour during which all salt water of the earth gets sweet.Since all the qualities occuring in the water depend exclusively upon the nature of the soil . . . These qualities are of stable nature . . . Therefore this statement . . . is entirely unfounded. Continual and leisurely experimentation will show to anyone the futility of this assertion."[4]

And finally this is what al-Bīrūnī wrote on geology, demonstrating his insistence on observation and logical deduction.

" . . . But if you see the soil of India with your own eyes and mediate on its nature, if you consider the rounded stones found in earth however deeply you dig, stones that are huge near the mountains and where the rivers have violent currents, stones that are of smaller size at a greater distance from the mountains and where the streams flow more slowly, stones

that appear pulverize in the shape of sand where the streams begin to stagnate near the mouths and near the sea — if you consider all this you can scarcely help thinking that India was once a sea, which by degrees has been filled up by the alluvium of the streams."[4]

In the words of the French scholar Briffault, "The Greeks systematized, generalized and theorized, but the patient ways of investigation, the accumulation of positive knowledge, the minute methods of science, detailed and prolonged observation and experimental enquiry were altogether alien to the Greek temperament . . . What we call science arose in Europe as a result of a new spirit of enquiry, of new methods of investigation, of the method of experimentation, observation, measurement and of the development of mathematics in form unknown to the Greeks. That spirit and those methods were introduced into the European mold by the Arabs . . . Modern science is the most momentous contribution of Islamic civilization."[10]

George Sarton puts these thoughts of Briffault in another way: "The main, as well as the least obvious, achievement of the Middle Ages was the creation of the experimental spirit, and this was primarily due to the Muslims down the 12th Century."[9]

The golden age of medical science in the Islamic world began somewhat earlier. The first translator and writer of independent medical works in Arabic was a Christian, Yūhannā Ibn Māsawi (known as Mesue Senior in the West), and after him his student Ḥunayn ibn Isḥāq. Ḥunayn translated not only the works of Hippocrates and Galen into Arabic but also an entire medical curriculum, the Alexandrian summaries. He also wrote the first systematic treatises on diseases of the eye. These Christian Arab pioneers were followed by the first notable Muslim physician in the first half of the 3rd/9th century, al-Ṭabarī, an Iranian convert to Islam. He wrote the first systematic Islamic work on medicine, "Firdus al-Ḥikmah". This included discussion of all branches of medicine as well as anatomy and a special section on Indian medicine. On this foundation, built by al-Ṭabarī and Ḥunayn, the golden age of Islamic medicine began with the work of the person we honour today in this lecture: Muḥammad ibn Zakariyyā al-Rāzī, probably the greatest of Muslim physicians. His experimental and clinical contributions were catalogued by al-Bīrūnī who listed 184 works, the most important of which was the encyclopedic al-Hāwī (Liber Continens), much prized in the West. His most famous work known in the West was on smallpox and measles "Kitāb al-judarī wal-ḥaṣbah." Following al-Rāzī, another Iranian dominated internal medicine in the eastern part of the Islamic world: al-Majūsī, known in the West as Haly Abbas. His contemporary in Muslim Spain was al-Zahrāwī (Albucasis), probably the greatest surgeon of the golden age of Islamic medical science, whose "Kitāb-al-Taṣrīf" or Concessio in Latin contained a section on surgical instrumentation and techniques. His works were widely disseminated in the West due to the Latin translation by Gerard of Cremona, and interest in this work survived into the modern period with a 1778 Oxford edition of the Arabic text with Latin translation.[8]

Space does not allow further discussion of other notable medical scientists including the "prince of physicians" Abū'Alī ibn Sīnā (Avicenna) who was born in Bukhārā and did most of his work in Persia; Ibn al-Nafīs, the discoverer of the pulmonary circulation and the real predecessor of William Harvey; al-'Afkānī, the Egyptian who wrote the first book on first aid, "The Refuge of the Intelligent during the Absence of the Physician"; and Ibn Rushd (Averroes), the most celebrated philosopher and physician of Andulusia, who wrote "Kitāb-al-Kulliyyāt" (the Book of General Principles — Colliget in Latin).

The Jewish physician and philosopher 'Abū'Imrān Mūsa ibn Maymūn (Maimonides) was a student of both Ibn Rushd and Ibn Ṭufayl. Accomplished in both medicine and philosophy, he became physician to Ṣalāḥ-ud-Dīn al-Ayyūbi (Saladin) and his family; his medical works include "The Book of Aphorisms" (Kitāb al-fuṣūl) and the "Regimen of Health", a book on hygiene dedicated to the son of Saladin.

The causes of the decline and interruption of the modern spirit of science which first dawned within the Islamic civilization remains unknown. The works of al-Bīrūnī and Ibn al-Haytham, of al-Rāzī and Ibn Sīnā did not directly lead to a continuous and permanent change in the direction of human sciences. Within a century or so after these men lived and worked, creation of first class science petered out and virtually came to a halt. About five centuries had to pass before the torch lit by scientists working in the Islamic world was rekindled and carried forward by Galileo, Copernicus, William Harvey, Leeuwenhook, Isaac Newton (who was born in the same year which Galileo died, 1642), and their contemporaries. It is tragic indeed that it has taken almost another 500 years for the Islamic world to realize that without modern science there is no possibility of survival in today's world.

The Decline of Science in Islamic Civilization

There have been many studies and books written on the "glory that was Islam", but very little on why that glorious civilization did not succeed in establishing what it first developed, a mature system for doing creative science and educating new scientists. A few Western scholars have attempted to address this problem, notably Marshall Hodgson in his magisterial work, "The Venture of Islam",[1] and Bernard Lewis in his book, "The Muslim Discovery of

Europe".[11] I have not been able to find any definitive book by a Muslim on this subject but my interest was aroused in this matter by an excellent analysis by Professor Abdus Salam, the first and only Nobel laureate (in physics) in the Muslim world. He asks the question, "Why did creative science die out in Islam?" Salam's analysis leads him to attribute the demise of living science within the Islamic commonwealth, which began around 1100 A.D. (c.e.) and was essentially completed by 1350 A.D. (c.e.), to internal rather than external causes. We will examine the latter first.

By external causes we usually understand such factors as being the Mongol invasion, the crusades, and the unfortunate and all too frequent recurrences of tribal and internecine warfare amongst Muslims themselves, who often placed tribal and national loyalities ahead of belief in Islam. This unfortunate tendency continues to this day. More recently we can add the long succession of military political defeats for Dār-ul-Islam symbolized by such episodes as the conquest of Egypt by Napolean, of the Mughal Empire by the British, the destruction of the Ottoman Empire and the subsequent Balkanization of the Arabian heartlands and the Middle East by the European powers. The latter set of events are particularly intriguing in helping us examine the paradox of the decline of science in the Muslim world, occurring almost at the same time as the geopolitical power of Muslim states was becoming more significant.

During the sixteenth century, in spite of the decline of creative science, geopolitically, the Muslim world constituted the most rapidly expanding force in world affairs. Not only were the Ottoman Turks pushing westward into Europe, but the Persians were enjoying a resurgence of power and high culture under 'Ismā'īl the First (1500-1624) and 'Abbās the First (1587-1629). A chain of strong Muslim khanates controlled the fabled "Silk Road" via Kashgar and Turfan to China, very much in the way that African Islamic states such as Bornu, Sokoto, and Timbuktu controlled the northern and central African trade. Hindu empires in Indonesia and India were overthrown by Muslim forces early in the sixteenth century. Under Akbar the Great (1556-1605) the Mughal Empire stretched from Baluchistan in the west to Bengal in the east. Vast numbers of new converts to Islam in Africa and Asia were made, far outstripping the proselytizing efforts of Christian missions in the same areas. The Ottoman Empire had conquered Hungary in the west, besieged Vienna repeatedly, and established a unity of official faith, culture and language over an area greater than the Roman Empire. Its cities were large, well illuminated, and had extensive sewage systems. In spite of continuing dominance in the early sixteenth century in mathematics, cartography, medicine and the technologies of mills, gun casting, lighthouses and horse breeding, by the second half of that century the Ottoman Turks began to falter, turn inward and lose their chance of world domination. In a superb historical account, Paul Kennedy has placed this collapse in the context of all great powers that have risen and fallen since 1500 to the present day. His emphasis is on the geo-political, economic, and military factors, particularly the latter. He blames strategic over-extension or "imperial overstretch", comparing the collapse of the Turkish, Spanish and British empires to a similar situation in the U.S.A. today, wherein the sum total of an empires' global interests and obligations exceeds its capacity to defend them simultaneously.[12]

The titular caliph of all Islam was the Sultan of the Ottoman Empire, who was also titled "Defender of the Holy Places" (Mecca, Medina and Jerusalem). In the West his forces maintained a large army in central Europe, an expensive navy in the Mediterranean, troops in North Africa, the Aegean, Cyprus and the Red Sea, with constant reinforcements needed to retain the Crimea against the rising Russian power. The official Sunni practice and teaching of the Ottoman Empire was now challenged by a disastrous religious split between the Shī'ah branch of Islam based in Iraq and later in Persia under 'Abbās the Great. Just as France had collaborated with the "infidel Turk" against the Holy Roman Empire, the Persians now allied themselves with the "infidel" Europeans against the largest Muslim power in the world. The fact that after 1566 a series of 13 thoroughly incompetent Sultans ruled the Empire was certainly an aggravating factor. Kennedy suggests an important point which applies very well to the thesis I am developing. He says, "External enemies and personal failings do not, however, provide the full explanation." He then goes on to cite the defects of being too highly centralized, despotic and severely orthodox towards any initiative and dissent. The fierce repression of the Shī'ah religious challenge (instead of any attempt at discusson and consensus building) "reflected and anticipated a hardening of official attitudes toward all forms of free thought." Printing presses were forbidden so that "dangerous" opinions would not be spread. Imports of Western goods were desired but exports were forbidden. Trade guilds received official support to check innovation and prevent the rise of "capitalist" producers. Contemptuous of European ideas and practices, the Turks refused to adopt newer methods to control plagues, consequently, the people suffered more severe epidemics. "In one truly amazing fit of obscurantism, a force of the elite Jannisaries destroyed a state observatory in 1580, alleging that it had caused a plague!"

Exactly analogous attitudes and practices were developing in that other center of Muslim power, the Mughal Empire. A conquering Muslim elite controll-

ed a vast population of poverty stricken peasants, mostly Hindus. In spite of a sophisticated banking and credit system and the availability of a strong commercial community in Hindu business families, the Mughal rulers (with exception of perhaps Akbar the Great) could not overcome certain indigenous retarding factors. The Hindu cast system, their religious taboos against modernization and the influence of obscurantist Brahmin priests over local Hindu rulers were coupled with marked distortions in the nature of Mughal rule. "The brilliant courts were centers of conspicuous consumption on a scale which the Sun King of Versailles might have thought excessive. Thousands of servants and couriers, extravagant clothes, jewels, harems and menageries, vast arrays of body guards could be paid for only by the creation of a systematic plunder machine. Tax collectors, required to produce fixed sums for their masters preyed mercilessly upon peasant and merchant alike; whatever the state of the harvest or trade, the money had to come in. There being no constitutional or other checks — apart from rebellion — upon such depredations, it was not surprising that taxation was known as 'eating'. For this colossal annual tribute, the population received next to nothing. There was little improvement in communications and no machinery for assistance in the event of famine, flood and plague — which were, of course, fairly regular occurrences."[12]

Thus the decline of the Mughal Empire, which is technically attributed to the failure to control the Afghanis in the North, the Marathas in the South and finally the East India Company of Great Britain, was due much more to internal factors than the external threats. Ironically, the greatest expansion of Mughal power in the Indian sub-continent under Aurangzeb was also coupled with a significant hardening of rigid orthodoxy and intolerance for deviations in the official interpretation of Islamic Law and teaching. It is no wonder that the collapse of the Mughal empire developed most rapidly after the death of Aurangzeb. Apart from ordering wholesale destruction of Hindu temples, Aurangzeb by his own confession, had neglected that side of the Shari'ah that called for protection and justice for the peasantry.[12,13]

Let us now examine more closely some of the internal factors which facilitated the decline of science in the Islamic world. The turn of the 11th to 12th century was a time of intense politically-motivated sectarian religious strife. Al-'Imām al-Ghazālī, in his "The Revival of Religious Learning," insisted that certain sciences were necessary (Fard Kifāyah) for the preservation of Islamic society, e.g., mathematics and medical science. In another of his books, "al-Munqidh min al-Ḍalāl," he could not have been clearer: "A grievous crime indeed against religion has been committed by a man who imagines that Islam is defended by the denial of the mathematical sciences, seeing that there is nothing in the revealed truth opposed to these sciences by way either of negation or affirmation, or nothing in these sciences opposed to the truth of religion." As Abdus Salam has said, "'Imām al-Ghazālī was fighting a losing battle." What appeared to develop from the 12th century onward was an increasing lack of tolerance for innovation "Ijtihād". Although technically "'ijtihād" stands for individual enquiry to establish the ruling of the Shari'ah upon a given point by a qualified person "mujtahid", I am using this term in a wider sense of innovative interpretation. It should also be noted that the Sunni branch of Islam had considered ijtihad permissable only on points not already decided by recognized authorities such as 'Abū Ḥanīfah (699-767 A.D. [c.e.]) and Aḥmad ibn Ḥanbal (780-855 A.D. [c.e.]). On points already so decided they required "taqlīd," i.e., adherence to the orthodox view. It is in this sense of demanding adherence and preventing innovation that this term "taqlīd" is being used. It should also be noted that the Shī'ah branch of Islam permitted full ijtihād, but only to their great scholars and not the ordinary Muslim.

Perhaps the most telling example of the depressing combination of apathy towards the continuation of creative science and a smug complacency towards the rigid orthodox religious view is found in a quotation from a surprising source. Ibn Khaldūn (1372-1406 A.D. [c.e.]), one of the greatest of social historians as well as one of the brightest intellects of any time, writes in his famous "al-Muqaddimah":

"We have heard, of late, that in the land of the Franks, and on the northern shores of the Mediterranean, there is a great cultivation of philosophical sciences. They are said to be studied there again, and to be taught in numerous classes. Existing systematic expositions of them are said to be comprehensive, the people who know them numerous, and the students of them very many . . . Allāh knows better what exists there . . . But it is clear that the problems of physics are of no importance for us in our religious affairs. Therefore, we must leave them alone."[14]

As Abdus Salam has emphasized in referring to this example, "Isolation in the sciences and the veneration of authority it engenders, spells intellectual death."[4]

Unfortunately, this lack of toleration for innovation and the confusion of scientific work with religious practice continued right through the history of the great Islamic empires. The Osmani Turks, the Iranian Safavis and Indian Mughals, with a few notable exceptions, continued the scientific decline even while importing European technology. William Eaton, British consult to Istanbul in the year 1800, wrote concerning the Turks, "The man of general science is unknown. No one has the least idea of

navigation and the use of the magnet . . . They like to trade with those who bring to them useful and valuable articles, without the labour of manufacturing."[15] Regretfully, in the majority of Islamic nations, this indolent attitude towards science and technology is not fully overcome even today. When one examines the utilization of the G.N.P. of Islamic nations today and tries to ascertain how much is devoted to the establishment of scientific institutions wherein science transfer from the West is emphasized as well as technology transfer, one finds only few examples of which to be proud. The number of scientists from Islamic countries is very small, 1/100 to 1/10 in size, in scientific resources and in scientific creativity, compared to international norms.[14]

Abdus Salam has noted in the paper referenced above that the confusion in Muslim thought about science and its relation to religion today may well be a legacy of the battles of yesteryear "when the so called 'rational philosphers' with their irrational and dogmatic faith in cosmological doctrines inherited from Aristotle formed difficulties in reconciling these with their faith."[14]

The confusion exists because Muslims who are not working scientists often do not have a clear idea of what science is and how religion relates to it. Modern science seeks rational understanding of the physical universe by observation and inference, and constructs knowledge on the objective basis of sense experience, and is essentially quantitative. Scientific theories are never perfect and no theory is acceptable unless it makes a sufficient number of valid predictions. If these predictions prove to be invalid, the theory is considered to be invalid. This effort is completely secular and does not appeal to divine authority for verification of scientific facts; but the existence of such authority is neither affirmed or denied by science. Some scientists are atheists or agnostics; others are deeply religious and continually in wonder at the order, precision and beauty of the universe and all things within it.

We may now understand how it is possible for a deeply religious Muslim, who does not do scientific work or realize what modern science is all about, to indeed become confused and try to create a new "Islamic Science." He may be genuinely concerned that practitioners of modern science inevitably become "rationalists" (modern Mu'tazllites) which in turn will lead to "shirk" and apostasy. On the other hand there may well be some who are truly obscurantists and see the new "Islamic Science" as a proper reaction to modern science, thus creating a false dichotomy of a religious science and irreligious science. In truth they are encouraging the development of a pseudoscience. Such confusion of thought, well described in analytic philosophy as "category mistakes", is not new and certainly not unique to Muslims. The Christian theologians of the Middle Ages had similar arguments with bitter denunciations and persecutions amongst themselves. Their questions were of the type: Does God move the primum mobile directly as an efficient cause or only as a final or ultimate cause? Do angels experience fatigue? Does celestial matter have inherent qualities like terrestrial matter? When Galileo first tried to classify such questions into those that properly belonged in physics and then sought to find answers only to those questions by physical experiments, he was persecuted by the Catholic Church. Three hundred and fifty years later, however, we read that at a special cermony for Nobel prize winners at the Vatican on May 9, 1983, His Holiness the Pope declared, "The Church's experience in the Galileo affair and after it, has led to a more mature attitude. The Church itself learns by experience and reflection and she now understands better the meaning that must be given to freedom of research . . . it is through research that one attains to Truth . . . This is why the Church is convinced that there can be no real contradiction between science and faith. However, it is only through humble and assiduous study that the Church learns to dissociate the essential of the faith from the scientific systems of a given age, especially when culturally influenced reading of the Bible seemed to be linked to an obligatory cosmogony."[4]

Evolution of scientific understanding in relation to religious thought in Islam analogous to that described above in Catholic Christianity is certainly ongoing now and is possible for all educated Muslims. The greatest potential asset of Islam is the frank sense of history that from the start has been a dominant fact in its discussions (even though some modernizing Muslims have displayed a romantic disregard of historical facts). Al-Shāfi'ī continued in his own work the example set by the Holy Prophet's life, when he insisted on understanding the Qur'ān quite concretely in its historical interaction with the life of the Prophet and his community. Although historical accuracy has not always been maintained, no Islamic scholar has ever denied the principle that historical accuracy was the foundation of all religious knowledge. Hodgson has suggested that it may be that Muslims "dare not admit that the historical Islam which is at the focus of their loyalties may be less perfect than the God with whom, in practice they tend to identify. But if there are Muslims whose confidence in God Himself is strong enough so that they dare risk everything, even community prestige or solidarity, for the sake of truth, then for such Muslims, facing historical realities and coming to terms with even the most painful of them is encouraged by the Islamic tradition itself."[1]

This sincere effort is needed if we are to reconcile within ourselves as Muslims the ability to work as scientists and continue to feel that our efforts are an essential part of a cosmic plan. The key element here

is the subjective point of view either reconciled with, or in creative tension with, an objective point of view, what Thomas Nagel has called "the view from nowhere."[16] Fortunately, there are an increasing number of scientifically literate Muslims today who have suceeded in this endeavor.

The moral crisis of the modern world is that preventable ignorance, hunger, disease and rampant human misery in an exploding world population coexist with highly sophisticated scientific techniques and knowledge which can ameliorate these problems. Thoughtful and well meaning scientists such as Roger Sperry and Jacque Monod hope to develop a value system for the modern world based on the ethics of science itself. This "scientific" fallacy is in a sense the opposite of the "religious" fallacy of an "Islamic" science, i.e., an analogous category mistake. In a fascinating review of modern physics, Paul Davis has shown how recent findings in science suggest that a predisposition to self-organization and increasing complexity is inherent within the laws of nature and that, in principle, science can explain the existence of complexity and organization at all levels including human consciousness, but only by embracing "higher level" laws. Davis admits that one view of these findings would be to deny a "God" or "purpose" in this creative universe; but "he does not see it that way." He sees instead the same facts and finds "powerful evidence" that "something is going on" behind it all, i.e., that there is a purpose and meaning to the universe.[17] This is exactly the stance of any scientist who also believes in God. In my own work in the field of neuroscience, I have developed a theory for the role of emotions in mental processes which explains how our need to know and to order information is regulated by our deeply felt beliefs. This fundamental mechanism of the mind, while being reducible to the physics and chemistry of the brain, is unique on earth to human brains and is very much a function of how we are designed (our genetic inheritance) and modulated by environmental interaction. The theory shows how subjectivity is prior to and regulatory of objectivity, with the latter's feedback expanding the range of subjectivity.[18] Thus, when we understand the inner dimensions of the message of Islam as well as ourselves, we begin to understand that it is indeed possible to comprehend how all our actions can be, to a great extent, self determined and yet in the service of God. Albert Einstein once said, "Science is a continual flight from wonder." I define the process in more detail as a movement from subjective wonder, through rational objective understanding and back again to wonder at the beauty and complexity of it all. The more we know, the more we seek to know. "'Inna Allāh Jamīlun, yuḥibbl-jamāl" (Verily God is beautiful and He loves beauty). Thus when we say "la 'ilāh illa Allāh" (There is no God but Allāh), we are affirming out faith in al-Tawḥid, and when we say "Muhammad Rasūl Allāh" (Muḥammad is the messenger of Allāh) we are affirming our belief in Muhammad as "al-insān-al-kāmil" and our desire to grow in this direction: a desire which can only be fulfilled by great knowledge.

I will end this address with a plea to all who read this to help science grow in the Islamic world. Help the institutions to grow and young scientists to develop and discover for themselves the power and limitations of science. Fear not for their spiritual values. The deeper one's knowledge of science grows the more one realizes how narrow a path it treads in the vast mysteries of space and time. The need to know more is never satisfied and spiritual growth inevitably follows with greater knowledge once the seeker realizes the limits of objectivity.

There is a wonderful story about al Bīrūnī told by a contemporary:

"I had heard that al-Bīrūnī was dying. I hurried to his house for a last look: one could see that he would not survive long. When they told him of my coming, he opened his eyes and said: Are you so and so? I said: yes. He said: I am told you know the resolution of a knotty problem in the laws of inheritance of Islam. And he alluded to a well known puzzle. I said: 'Abū Raḥān, at this time? And al-Bīrūnī replied: "Don't you think it is better that I should die knowing rather than ignorant?" With sorrow in my head I told him what I knew. Taking my leave I had not yet crossed the portals of his house when the cry arose from inside: al Bīrūnī is dead."[4]

In conclusion I would like to quote a verse from the Qur'ān which best captures the sense of wonder which is so fundamental in both science and religion as well as suggesting their relation to each other:

"And if all the trees on earth were pens and all seas were ink, with seven seas, after, to replenish it, yet would the words of Allāh be never spent, for Allāh is mighty and all wise."[19]

References

1. Hodgson M: The Venture of Islam. Volumes I, II, III. Chicago: University of Chicago Press, 1974.
2. Monod J: Chance and Necessity. Collins, 1972.
3. Glorious Qur'ān, Chapter 3, Verses 190-191.
4. Salam A: Islam and Science. Corcordance of Conflict? Paris: UNESCO House, April, 1984.
5. Glorious Qur'ān, Chapter 36, Verse 82.
6. Nasr S: Science and Civilization in Islam. Cambridge, MA, 1968.
7. Schuon F: Understanding Islam. Translated by S Matheson, London, 1961.
8. Nasr S: Islamic Science. An Illustrated Study. Westerham, UK: World of Islam Festival Publishing Co, 1976.

9. Sarton G: Introduction of the History of Science. Three volumes. Baltimore: Williams & Wilkins, 1945.
10. Briffault M: Making of Humanity. Quoted by M Iqbal in the "Reconstruction of Religious Thought in Islam". Lahore, 1971.
11. Lewis B: The Muslim Discovery of Europe. New York: W. W. Norton & Co., 1982.
12. Kennedy P: The Rise and Fall of the Great Powers: Economic Change and Military Conflict from 1500 to 2000. Random House, 1987.
13. Ikram S: History of Muslim Civilization in India and Pakistan. Lahore: Star Book Depot, 1962.
14. Salam A: The Gulf University and Science in the Arab Islamic Commonwealth. Presented at the Symposium: "Future Outlook of the Arabian Gulf University". Bahrain, May, 1983.
15. Eaton W: A Survey of the Turkish Empire. 4th Edition. London, 1809.
16. Nagel T: The View from Nowhere. Oxford: Oxford University Press, 1986.
17. Davies P: The Cosmic Blueprint: New Discoveries in Nature's Creative Ability to Order the Universe. New York: Simon & Schuster, 1988.
18. Ommaya A: The role of emotions in the processing of information by the brain. Presented at the Smithsonian Resident Associate Program on "Art, Science, and Religion", Washington, DC, 1987.
19. Glorious Qur'ān, Chapter 31, Verse 27.