Khan Bahadur Ahsanullah Memorial Lecture

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FIRST LECTURE

Science, Technology and Muslim World – From a Golden Age to Stagnation

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1. Introduction

A paradigm shift has occurred in the last few decades in the development and application of science and technology, which has affected in fundamental ways the whole range of activities in manufacturing, services and agriculture. The intellectual component, and hence the "technology content", is significantly increasing in all products and services which an entrepreneur wishes to produce and provide. It is quite obvious that technology has become pervasive. Technology is often credited with being the single most outstanding factor, which has facilitated accumulation of Intellectual Capital in the modern Western industrial world. In the two and half centuries between 1473 and 1727, one of the greatest intellectual revolution in human history occurred — the Scientific Revolution — initiated by the work of a relatively small group of geniuses working in the universities of Western Europe. This was obviously the early precursor of the technological revolution and aggregation of scientific and technological (S&T) capital that has taken place in recent times. However, the progress of S&T development that is currently associated almost completely with Western Civilization was the product of knowledge and major inventions made by older civilizations like Chinese, Indian, Islamic etc.

Islamic or Muslim seats of civilization did demonstrate elements of "creativity" and "innovation" centuries before the relatively recent scientific and technological revolution and consequent dominant position of the West. During the second half of the twentieth century there has been a general awakening in the developing countries on the need for 'catching up' with the West with respect to Science and Technology and removing the "road blocks" in the path of scientific development. However, Muslim countries over the past centuries have not fared well compared to others in their policies and plans for adoption of scientific methods of inquiry, creation of a climate for innovation and adaptation of modern technology.

The countries chosen for these discussions in this article were not averse to scientific enquiries, technological innovations and entrepreneurial courage to challenge the status quo during some periods of their earlier history. The Timeline of Islamic Scientists shown in Appendix A at the end of this paper is ample testimony to this historical reality. Yet, as we shall endeavor to demonstrate, some social, cultural, political events and economic determinants during subsequent periods of history caused a paradigm shift towards orthodoxy, obscurantism and regressive policies which enforced limits on scientific and technological developments. We shall also focus on the relationship between some socio-cultural factors and technology in order to identify in general terms some of the negative elements in the socio-economic systems prevailing in these countries which are believed to have acted as disincentives for developing the innate "courage to act" in favor of accumulation of scientific and technological capacity (Mahmud, 2005).

2. The Problem

In this section we shall endeavor to rank the Muslim countries, chosen for discussion in this paper, in terms of some generally accepted composite indices and compare them with ranking of technologically advanced countries. We think the numbers shown in the tables will provide a rough idea of the level of achievement and current trends for accumulation of scientific and technological capital in these countries. The differences in levels will be evident from the tables. The two composite indices used for the purpose are as follows:

a. **Human Development Index (HDI) published by UNDP**
b. **Technology Achievement Index (TAI) developed by Desai, Sagasti and others (Desai, 2001) for the Human Development Report 2001.**

The HDI is based on three indicators: longevity, as measured by life expectancy at birth; educational attainment as measured by a combination of the adult literacy rate and the combined gross primary, secondary and tertiary enrolment ratio; and standard of living, as measured by GDP per capita (Purchasing Power Parity, US $).

The TAI (Technology Achievement Index) focuses on four dimensions of technological capacity those are important for reaping the benefits of network age. The methodology used to calculate the TAI is similar to the human development index: a simple average of the dimension of the index, which in turn is calculated based on the selected indicators. The TAI has eight indicators, two in each of the four dimensions:

- Technology creation measured by the number of patents granted to residents per capita and by receipts of royalties and license fees from abroad per capita.

- Diffusion of recent innovations, measured by the number of Internet hosts per capita and the share of high-and medium-technology exports in total goods exports.
- Diffusion of old innovations, measured by telephones (mainline and cellular) per capita and electricity consumption per capita.
- Human skills, measured by mean years of schooling in the population aged 15 and above and the gross tertiary science enrolment ratio.

TAI estimates have been prepared for 72 countries for which data are available and of acceptable quality. For others, data were missing or unsatisfactory for one or more indicators, so the TAI could not be estimated. For a number of countries in the developing world, data on patents and royalties are missing. Because a lack of data generally indicates that little formal innovation is occurring, a value of zero for the missing indicator was used in these cases. The results shown in the tables (Tables 1 and 2) below indicate that there are great disparities between Muslim countries and technologically advanced countries of the West.

Table 1: Human Development and Technology Achievement Indices of some Muslim Countries

Country	**HDI Ranking (2007-08)**	**TAI Ranking (2001) [Only 72 countries were ranked]**
Algeria	104	58
Bangladesh	140	NA
Egypt	112	57
Indonesia	107	60
Iran	94	50
Jordan	86	NA
Kuwait	33	NA
Lebanon	88	NA
Malaysia	63	30
Pakistan	136	65
Saudi Arabia	61	NA
Syria	106	56
Tunisia	91	51
The “Spread”	**(33-140)**	**(50-65)**

Table 2: Human Development and Technology Achievement Indices of some Technologically Advanced Countries

Country	HDI Ranking (2007-08)	TAI Ranking (2001) [Only 72 countries were ranked]
Australia	3	10
Belgium	17	14
Brazil	43	43
Canada	4	9
Croatia	47	31
Germany	22	11
Hong Kong	21	24
Israel	23	18
Japan	8	4
Korea(South)	26	5
Netherlands	9	6
UK	16	7
United States	12	2
The "Spread"	**(3-47)**	**(2-43)**

In the two tables shown above (Tables 1 to 2) the HDI and TAI ranking for selected Muslim and technologically advanced countries have been presented. Given the methodological problems involved, no attempt has been made to find "group averages". However the so-called "spread" for each group has been indicated. Given the higher availability of natural resources and much lower population density, one would at least expect that the Middle East region should have been well ahead. However, the results appear to be disappointing. We feel that in addition to HDI and TAI rankings the reader needs to look at some pertinent country data given in Appendix B which clearly demonstrate their commitment to S&T, connectivity to the word communication network, number of local innovations and extent of R&D efforts.

Data drawn from UN Human Development Report 2007 have been presented in Appendix B at the end of this paper. In the tables, along with HDI rankings, the score of each country with respect to the following issues has been tabulated:

- Internet Users,
- Patents Granted to Residents,
- Receipt of Royalties,
- R&D Expenditure, and
- Number of Researchers

A cursory glance at the two tables in the Appendix will show the stark difference between the selected Muslim countries and those of the West with respect to technology acquisition and diffusion. In the columns showing data for "Patents Granted" and "Receipt of Royalties", Muslim countries score very poorly indeed (almost zero)! In terms of investment in R&D the figures speak for themselves. Thus, problems faced by these countries with respect to S&T development are indeed daunting.

3. The Golden Age

In this section we present a brief history of science and technology in the Muslim world. The Muslim experience consists of a golden age in the tenth through thirteenth centuries, a subsequent decline, a modest rebirth in the nineteenth century, and a history of frustration in the twentieth century. The deficiency in Muslim science and technology is particularly intriguing given that Muslims were world leaders in science and technology a millennium ago -- something that distinguishes them from, say, the peoples of Latin America or sub-Saharan Africa (Segal, 1996). From the tenth through the thirteenth centuries Muslim countries occupied a predominant leadership role in scientific and technical innovation. The economic integration of the trading worlds of the Mediterranean and Indian Oceans under a common language and culture stimulated growth through both the larger market it generated and the exchange of scientific and technical knowledge (Lal, 1999). This region probably anticipated the expansion and influenced the expansion of Western Europe. In spreading to Spain in the west to India and Southeast Asia in the east, these countries unified much of Eurasia and Africa and took over and created the first global system. Through this culture, albeit an Islamic one, the technological achievements of China and India were diffused throughout Western Europe.

During this period Arabs became heirs of the ancient civilizations of western Asia and northern Africa. Baghdad in the ninth century was the scene of intense intellectual activity. With the active inspiration of the kings (Caliphs) a number of eminent scientists worked in the House of Wisdom (Baitul Hikma) a kind of research institute for scientific and technological innovation. They rend major Hellenistic works from Greek into Arabic. These translations and those from Indian sources gave impetus for genesis and development of new knowledge. In the course of the century original works were written on mathematics, astronomy, physics and medicine. In the field of technology they continued the innovative culture of their Persian predecessors constructing and innovating large hydraulic systems, building water-raising wheels and large mills for supplying the city with flour. In the case of more delicate machines, a treatise written about 850 AD describes about 100 ingenious devices which display a mastery over sensitive control mechanisms that remained unsurpassed until modern times (Hill, 1993, Nasr, 1976). However these devices were of small "pilot scale" and were never scaled up to put into general service for productivity increases in economic activities. Possibly these were developed as intellectual challenges and not innovated to meet industrial needs.

Scholars of these eras were the first to recognize importance of and use of zero (borrowed from Indian sources), founded modern Algebra (by Al-Khawarzimi) and made monumental strides in the practice and study of medicine. Ibn Sina's (Avecinna) text the Canon of Medicine was used as a text in Europe centuries later (Tarabishy, 2004). Scientific endeavors in this region lasted for nearly six centuries and this, as George Sarton (Sarton, 1975) observed, is longer than Greek, medieval Christian, or even modern science has lasted. Karen Armstrong (Armstrong, 1991) writes “The Arabs were light to the … West and yet this debt has rarely been fully acknowledged. As the great translation work had been completed, scholars in Europe began to shrug off this complicating and schizophrenic relationship… And became very vague indeed about whom the Arabs really were…"

George Sarton in his monumental work marks the time from the 2nd half of eighth century to the 2nd half of the eleventh century into:

- The time of Jabir Ibn Haiyan which covers the 2nd half of eighth century
- The time of Al-Khwarizmi which covers the 1st half of ninth century
- The time of Al-Razi which covers the 2nd half of ninth century
- The time of Al-Mas'udi which covers the 1st half of tenth century
- The time of Abu-l-Wafa which covers the 2nd half of tenth century
- The time of Al-Biruni which covers the 1st half eleventh century
- The time of Omar Khyyam which covers the 2nd half of eleventh century

The Golden Age for Muslims as the leaders in science continued until the 14th century. The highlight of this era was in the 10th and 11th centuries when three great thinkers strode the East: Abu Ali al- Hasan ibn al-Haytham, also known as Alhazen; Abu Rayham Muhammad al-Biruni; and Abu Ali al-Hussein Ibn Sina, also known as Avicenna. Al-Haytham, born in Iraq in 965, experimented with light and vision, laying the foundation for modern optics and for the notion that science should be based on experiment as well as on philosophical arguments. It has been suggested that al-Haytham “ranks with Archimedes, Kepler and Newton as a great mathematical scientist”. The mathematician, astronomer and geographer al-Biruni, born in what is now part of Uzbekistan in 973, wrote some 146 works totaling 13,000 pages, including a vast sociological and geographical study of India. Ibn Sina was a physician and philosopher born near Bukhara, also now in Uzbekistan, in 981-1037. He wrote al-Qanun fi al-Tibb, or The Canons of Medicine, a million-word medical encyclopedia, a seminal volume that was the first to recognize the contagious nature of tuberculosis, to identify meningitis, and to describe all the minute parts of the eye. By the 12th century, the Canons had been translated into Latin, and European medicine relied on this text until well into the 1700s. Thus, if it were not for these Islamic scholars, developments in Western sciences may not have advanced as much as they had (Habibi, 2008).

Technology: Between 750 and 1100 AD, the Muslim world had a number of impressive technological achievements to its credit, in addition to being a more tolerant and cultured society (Singer, 1958). This included development of "Lateen Sail" which allowed building of larger merchant ships. In power technology, Muslims were the first to use a tidal mill in Basra around 1000 AD. Both wind mills and water power were used in sugar mills and saw mills.

Muslims were also responsible for the introduction of paper into the Middle East and Europe. By 1000 AD the entire Islamic world was enjoying bound books. In textile production, the Muslim world made substantial advances in fabric quality. Most original contribution was in Chemical Technology. Al Jabir and Al Razi wrote books which for centuries were recognized as standard works in the field. They invented Alkalis and greatly improved the quality of glass and ceramic products. They produced naptha and their perfumery and acid industries were advanced for that age.

In Mechanical Engineering, from water mills to clocks, the Muslims were for centuries far ahead of the West. Al Jazari's "Book of Knowledge of Ingenious Mechanical Devices" has been recognized as the most remarkable engineering document to have survived Pre-Renaissance times (Hill, 1993). They were masters in the utilization and modification of hydraulic technology. Spread of irrigation helped agricultural progress and between 700 and 1100 AD "Agricultural Revolution" occurred in areas populated by Muslims (Mokyr, 1990).

4. Stagnation and Decline

The economic decline of the Middle Eastern countries relative to Europe (given their geographical proximity) has been a continuing puzzle to both scholars and reformers. The puzzle is confounded by the fact of their earlier dominance alluded to in the section above (Ruttan, 2001). The first wave of destruction of centers of learning and innovation came during Mongol invasion of Middle Eastern heartland. Sack of Baghdad destroyed records of achievements of scholars and scientists referred to above.

The Mongols, after their conquest, converted to Islam but took an ambivalent attitude towards knowledge accumulation. A section of religious teachers of the time connived with the powers that be to remove secular subjects from the school curricula. Scholars between the ninth and eleventh centuries concluded that answers to all-important question were already available and, thus, students needed only to learn existing knowledge. This approach to education resulted in rote learning and a culturally inward focus, which served to stifle creativity, and suppress technological innovation (Kuran, 1997). This inward focus prevented the Middle Eastern countries from engaging in a meaningful intellectual exploration of the technological transformation taking place in Europe. Scholars of this region of the seventeenth and eighteenth centuries were aware of the decline of their civilization but saw Europe's advantage as consisting essentially of superior weaponry, failing to analyze the deeper causes. Ottoman rulers, too, fearing corrupting influences from the West, closed their cultures to exchanges with and diffusion from next door Europe (see section 5[d] below).

To illustrate the apathy towards the creation of sciences, which came over the Muslim countries, Nobel Laureate Professor Abdus Salam quotes from Ibn Khaldun (1332-1406 AD), one of the greatest social historians and one of the brightest intellects of all times in his own field. Ibn Khaldun writes in his Muqaddima:

"We have heard, of late, that in the land of the Franks, and on the northern shores of the Mediterranean, there is great cultivation of philosophical sciences. They are said to be studied there again, and to be taught in numerous classes…….But it is clear that the problems of physics are of no important for us in our religious affairs. Therefore, we must leave them alone" (Salam, 1986). Such apathy must have led the inevitable distrust of sciences as essential to intellectual enrichment. Leading jurists in those times understood "ilm" (knowledge) as referring to that knowledge which derives from the Prophet (PBUH). Everything else are to be regarded either as useless or no science at all. Such beliefs are still prevalent among the puritan clergy (Ulama) in Islam.

Anti-intellectual activities in the Middle Eastern countries were started much earlier. Even though prevalence of an organized Clergy or "Ordained Priests" is not legitimized by Islamic dogma, the religious teachers and scholars (Ulama) were able to assume a similar role and received legitimacy from general public. After the demise of the "rational" period the "Ulama" were able to promote a slide towards acceptance of a "tradition and compliance" regime from an earlier one which had encouraged "innovation". Decline of science in Middle Eastern culture was contemporaneous with the ascendancy of an ossified religiosity. The rumblings against rational thinking and culture of science and technological innovations were there and leading "Ulamas" worked tirelessly to rid the culture of "foreign" intrusion of thought. Some of the leading Islamic theologians of the Fourteenth century condemned study of mathematics with vigor and without reservations because its precision and logical clarity might lead to disbelief and contempt for religious edicts (Hoodbhoy, 2002). Finally the "Golden Age" of Middle East ended in the 14th century.

Unfortunately majority of Muslim theologians of today neither have the necessary training nor the intellectual background to appreciate the methods of scientific enquiry. Their intellectual universe is limited to medieval theology. This medieval theology becomes their power and any one opposing may be declared heretic. They have often endeavored to assume the power of excommunication reminiscent of the Christian clergy in the medieval times.

The Muslim world has not systematically debated the issue of the reconciliation of Islam with science and technology. Few theologians are interested in dealing with this issue. Few scientists wish to incur the wrath of the religious community by publicly raising it. In most Muslim countries a tacit agreement therefore exists between scientists and theologians not to debate issues that could harm both sides. However, the religious leaders seldom speak against the tenets of science and scientific doctrines and concepts are, fortunately, free from religious challenge. The teachings of Darwin on evolution, for example, are allowed everywhere but Saudi Arabia (Segal, 1996).

5. Essential Ingredients of a "Technology Culture"

Before going into the identification of the specific elements or factors which result in the vicious circles in the Muslim countries, perhaps it would be prudent at this stage to briefly introduce the concept of "technology culture". Technology culture refers to an attitude of individuals in a given cultural environ. The spirit of inquiry, the degree of acceptance of the right to question and be questioned is to be considered fundamental to the development of technological temper. It calls upon one to seek the "hows", "what" and "why" of everything that goes on in the society. The existence of a technology culture is complementary to the initiative taken by a country in the introduction of productive forces, which can lead to technological development. A socio-economic entity may decide to develop the "object embodied form" (i.e. the hardware) of technology based on its relevant factor endowments existing at a given period of time. However, simultaneous development of the other three "soft" components i.e., "human embodied form", "information embodied form" and "organization embodied form" of technology constitute the more innovative and intellectual aspects and presupposes existence of a technology culture in the country. For the sake of simplicity it is assumed that such a culture exist in a well developed form in all leading industrial countries and developing countries are currently at various stages of acquiring it in a form complementary to their own societal ambience. However, in this mission to develop a technology culture, they are also engaged in the process of removing some "road blocks". We discuss below some of those "road blocks" or "negative elements" which probably are more significant than others among the myriad of causes of uneven progress in embracing a technology culture Muslim countries.

a) Traditional Value System and Orthodoxy

Distrust of new technologies is deeply rooted in most cultures with old value systems because people in general are resistant to change. The fears of changes that usually follow introduction of new technology results from the belief that these changes are likely to be adverse. New technology, be it the product of local development, a transfer from abroad, or some combination of the two, carries with it implicit behavioral changes which may not be consonant with existing traditional values. Scientific and technological changes can undercut systems of belief with behavioral implication far beyond those necessary to carry on the scientific and technological endeavor. In our discussion on these issues we shall look at some historical instances of technological change and their relationships to other dimensions of culture and try to discern some insights into the nature of the process and the range of possible consequence. It will seem that there is always a fear in a society steeped in orthodoxy (evident even in western cultures during earlier centuries) that something important (e.g. cosmological belief, family values, social equilibrium among classes, etc.) would be lost as a result of the new technology (DeGregori, 1989).

This reality coincides with the conflict of belief between conservative or puritan Muslims and the so-called Westernized Muslim scientists who could separate out the science and religious. For example, some typical comments from puritans include "Since all knowledge is in the Great Text, there is no need to provide incentive to seek new frontiers of knowledge" and "It's destructive if we want to create a thinking person, someone who can analyze, question and create" (Habibi, 2008).

b) Ancient Habits of Resignation

Many people in these countries continue to view life as a zero-sum game. They seem to believe that there is a limited pie of resources and attempt to expand resources through some form of innovation is likely to result in a smaller share of the pie for them. Increased productivity can increase the pie for everyone, yet in many countries people have not made this mental shift and are resigned to the older modes of production. People resigned to the cultural perspective of life as a zero-sum game seem to resist learning the lesson that exploiting areas of overlapping interests expands the pie for everyone (Weisenfeld, 2003).

c) Stratified and Exclusive Societies

People may possess identical material and intellectual resources and yet be treated as unequal because of social stigma or due to the denigration of the world-view that informs their way of life and frames their identity (Bhargava, 2004). Many Muslim countries still retain stratified social structures that resist change. Such exclusive societies restrict social mobility, which is considered fundamental in building a dynamic cultural milieu. In some areas the colonial legacies and in others ancient pseudo-religious practices and beliefs exacerbate their problem. Culturally rigid social stratification in such exclusive societies artificially reduces the availability of appropriate human resource for development. Meritocracy is not encouraged and the excluded section of the society is resigned to the rule of the established elite even when their members are mediocre. Thus, the urge to excel is lost and the spirit of competitiveness is repressed.

A negative element in the culture of some Muslim countries that merits serious attention is the exclusion of women from intellectual and social intercourse. The exclusion of women from participation in cultural, intellectual, economic and political spheres of activities was not ordained during the Prophet's lifetime but was introduced through edicts handed down afterwards by his followers to address certain social exigencies of those times. Such injunctions appear to have continued over centuries to the advantage and convenience of male dominated cultural milieu giving rise to exclusive societies in these countries.

d) Highly Centralized Bureaucratic Decision-Making Systems Discouraging Diffusion of Ideas and Technologies

Almost all cultures in the world have been borrowers of technology throughout history. A vast majority of the technology in a culture was, in all probability, developed by others. Most innovations are borrowed from other societies and improved upon. In fact, for several centuries there was a continuous and fruitful (occasionally not so fruitful!) interchange of tools and diffusion of ideas in the area that included South Asia on the east and stretched to Europe in the West. Useful technologies spread, either through migration of populations or by diffusion of techniques to neighboring population both within and outside a given geo-political region (Cravens, 2003). The diffusion of technology is critical and often more important than its invention, because most complex technological advances depend upon previous mastery of basic problems. Thus technology develops in a cultural ambiance which welcomes cross border diffusion and exchanges.

Unfortunately, however, in the countries under discussion there have been periods when some ruling elites or powerful centralized bureaucracies consciously opted out of the interchange and diffusion process thus stymieing local innovation activities. Such isolationist policies can be adopted and implemented only when a ruling elite or highly centralized bureaucracy in a country exists and purposely opts for them. Such an option is often exercised out of fear of “corrupting” influence of new technologies or due to complacency resulting from a belief that answers to all-important questions is already available. In general, centralized systems stifle innovation.

Most of the countries under discussion have highly centralized system of government. Egypt, which probably invented centralized bureaucracy in Pharaonic times, remains largely centralized today. Ottoman Empire was also run as highly centralized bureaucracy. Ottoman rulers, fearing “corrupting” cultural influences from the West, closed their society to exchanges with Europe as the latter began to take off. This was one of the factors contributing to the decline of technological innovations in the Ottoman Empire, compared to the Middle Ages, when the Islamic civilization led the world in science and technology.

6. Islam and Science

Religion has played an important role in the economic and political culture of the Middle East and other Muslim countries. Looking back, one finds that the kind of Islam and the cultural roots that it formed in the Middle East at the time of the Prophet (PBUH) was neither monolithic nor normative: it was in constant flux as it was developing throughout the Prophet's career. Seeking knowledge had been one of the more important injunctions of the Prophet (PBUH) in a cultural milieu that hardly had any tradition of scientific inquiry at that time. In one of his injunctions he exhorts his followers "Seek knowledge even if you have to go to Cathay (China)." It should be taken into consideration that in the sixth century there were no adherents of the religion in China, however she was the foremost center of scientific learning in those times. Since the beginning of Islam there has been many different understandings of this religion each identified by its historical time and locality, and with multiple contents, not always in harmony with each other (Gutas, 2003). As posited earlier, cultural developments in the Middle East have been significantly influenced by Islam throughout history and these have impacted differently in encouraging or discouraging scientific inquiry and technological innovations depending on political exigencies and whose interest the religious leaders preferred to promote. Therefore, in judging the influence of Islam on development of S&T there is hardly any need to question whether it is for or against science and technological innovation because throughout history religious arguments (in all cultures) have been found for any position.

Western observers and “orientalists” more often than not ascribe the apathy for S&T developments in Muslim countries today to Islam. We would like to posit that such an impression is quite erroneous. The blame for the apparent backwardness of Muslim countries in S&T does not and should not go to Islam per se as is often propagated by many western observers. There is nothing in the Quran, which discourages acquisition of knowledge and the Prophet also made acquisition of knowledge obligatory for believers. As mentioned in earlier paragraph he enjoined his followers to seek knowledge even if they had to travel to far Cathay (China) in its search.

One of the most important Quranic commands is for individuals to seek knowledge and read nature for signs of the Allah (SWT). Seven hundred and fifty verses (almost one eighth of the Book) exhort believers to study nature, to reflect, to listen, or to observe (for instance, see, sura 30, verses 21 to 24) in their search for the ultimate. Also see sura 41, verses 53-54, “Soon WE will show them Our Signs in farthest regions of the earth and among their own people until it becomes manifest to them that it is the truth. It is not enough that thy Lord is Witness over all things? Aye, they are, surely, in doubt concerning the meeting with their Lord; aye, HE, certainly, encompasses all things”. Interestingly, there are only eight verses on Hajj (one of the five pillars of Islam) and only six on fasting in the month of Ramadan (another pillar). Whereas, there are several hundred verses on issues related to sciences, natural phenomena, etc.

In the whole of Islamic history there has rarely been incident like that of organized persecution by the Christian clergy of the great scientist Galileo. Persecution, denunciation, excommunication do occur in Islam over doctrinal differences, but never for scientific beliefs. Paradoxically, the first inquisition (like that of medieval Catholic Church) came to be instituted, not by orthodox theologians, but by the so-called “rationalists”, the Mu’tazzila-theologians themselves who prided on the use of reason. The great jurist Imam Ahmad ibn Hanbal was one of the victims (Salam, 1986).

Some authors posit that what a particular society accomplishes in the way of science wholly depends on who is using that religion or ideology and to what ends. The analysis of scientific activity in Muslim countries, therefore, should proceed only from the investigation of the social and political factors at play in each particular time of history (Gutas, 2003). Gutas illustrates this point succinctly thus*: "In which modern state of the Islamic world there is a research library of the caliber of a major American or northern European university library, with open stacks and borrowing privileges? It is instructive to compare this situation in the modern Islamic world with that in the medieval, when there was a plethora of libraries with holdings in all the arts and sciences, especially in Baghdad……The current scientific backwardness of the Islamic world, just like its medieval superiority, is thus clearly a political and social issue……Injecting the notion of "Islam" into these discussions merely obfuscates the issue and confuses the students, distracting them from historical analysis and political action."*

Recently, there has been a move to find roots of an "Islamic Science" or "Islamization of Science". Such moves may have been inspired by a desire to placate the "Ulama". In this context we are in full agreement with the view that there cannot be an Islamic science as there cannot be a Christian or Hindu science for the physical world. This is in no way a discredit to a religion because the purpose of religion is to improve morality rather than specify each and every scientific principle (Hoodbhoy, 2002).

7. Efforts for Reformation

Several attempts were made during the 19th century for "reformation" of the concept held by "Ulama" that worthwhile knowledge acquisition ought to be restricted to religious knowledge. However, political turmoil and wars for over a century in the region probably prevented such revivalist initiatives to gel. We now briefly cite the important messages from three of the leading reformists (quoted from "Islam and Modernism", Eagle Enterprises, 2003[internet]).

Jamal al-Din al-Afghani (1839-1897), the pioneer of pan-Islamism, was convinced that nothing but science and technology could eliminate economic and cultural backwardness. Afghani objected to dividing science into European and Muslim. He said modern science as universal, transcending nations, cultures and religion. Afghani criticized the Muslim scholars for not seeing it that way by saying: "The strangest thing of all is that our Ulama these days have divided science into two parts. One they call Muslim science, and one European science. Because of this they forbid others to teach some of the useful sciences." Afghani was indignant that natural science was left out of the curriculum of Muslim educational establishments. He said: “Those who imagine that they are saving religion by imposing a ban on some sciences and knowledge are enemies of religion.”

Sheikh Mohammad Abduh (1849-1905), the Chief Mufti of Egypt argued that traditional Islam faced serious challenge by the modern, rational and scientific thought. But he did not believe that the faith of Islam in its pure and permanent core of norms clashed with science. Instead he asserted that the faith and scientific reason operate at different levels. The real Islam, he maintained: "had simple doctrinal structure: it consisted of certain beliefs about the greatest questions of human life, and certain general principles of human conduct. To enable us to reach these beliefs and embody them in our lives both reason and revelation are essential. They neither possess separate spheres nor conflict with each other in the same sphere…" He was sincerely interested in eliminating the obstacles to the development of science and technology essential for the revival of the Muslim peoples and for economic and cultural progress. He wanted Muslims to use scientific achievements without heed of the world outlook implicit in science.

Sir Sayyed Ahmad Khan (1817-1898), the pioneer of Indian Muslim reform, basically subscribed to the same ideas of Islamic reform as Sheikh Abduh. Both agreed to the point of necessity to harmonize Islam with modern science and rationalism. Sir Sayyed, however, viewed revelation by the criterion of its conformity to Nature. To him, Islam was the religion of most akin to Nature. Reason and “conformity to Nature” according to Sir Sayyed was the essence of Islam. His main argument was that the Quran was the word of God and the nature was the work of God; a disparity between the two was unthinkable. According to him, Wahy (revelation) and reason are identical. The latter operates in man's scientific investigations as much as in his concept of deity, his distinction between good and evil, his views on divine judgment and retribution, and his belief in life after death.

8. Conclusions: ***Need for Nurturing of Questioning Minds***

Since the later half of the last century the products of scientific research and technological innovation have given rise to a “knowledge society”. According to Peter Drucker, “The emerging (knowledge) society is the first society in which ordinary people — and that means most people—do not earn their bread by the sweat of their brow” (Drucker, 1968). Presumably he was referring to “knowledge workers” and “Intellectual Entrepreneurs” exploiting the benefits of advances in S&T in the industrialized nations. Given the knowledge "explosion" that is taking place in this century it is pertinent to note "it took from the time of Christ to the mid eighteenth century for knowledge to double. It doubled again 150 years later and then again in only 50 years. Today it doubles every 4 or 5 years. More new information has been produced in the last 30 years than in the previous 5000 years" (Linowes, 1990).

The above quotes clearly establish the compelling reasons for a massive shift towards cultivation of S&T in Muslim countries. The response of a majority of countries to the need for S&T modernization has been to import technology to meet the knowledge gap. Plans for education reforms often converge on proposals to import computers, involve foreign experts/consultants (encouraged by donors), fund health care diagnostic laboratories etc. We do not deny that some of these are necessary technologies (mostly in the form of hardware).

However, creating an environment that inspires local talent to innovate requires additional efforts in terms of openness to cross-border exchange and diffusion of scientific ideas, exchange of faculty and students, creating atmosphere for intramural dialogue and cross-sectoral debate, and the *conscious promotion of questioning minds and creativity in the curricula at every level.* Such determined and purposeful initiatives are evident only in a few Muslim countries. What is absent is a system of tertiary education that can play the key role in generating and applying knowledge in this network age that can help produce world standard S&T and narrow the ever widening knowledge gap (Sharif, 2004).

Commitments to education in general and tertiary sector in particular are substantial and the fraction of tertiary students in S&T subjects is considerable in some Muslim countries. Yet their achievements in terms of scientific discoveries and technological innovations (e.g. patents and payments received from royalties) have been minimal (see Appendix B). It is possible that the effort to give a boost to S&T development has been made only recently and one has to give time for the gestation period. However one is wary of the prevailing mind-set and the manner in which science and engineering are being taught. One would like to be assured that the curricula have been designed to test the creativity of the young mind which can help him or her to develop a questioning mind.

It is imperative that the countries take initiatives for shedding bureaucratic and cultural hangovers of the past. This is possible if enlightened leadership is provided from the top and courageous initiatives taken to counter obscurantism. The Muslim countries have to concentrate its investment in human resources and purposefully encourage questioning minds to extend the frontiers of knowledge.

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Appendix A

Timeline of Islamic Scientists (700-1400)

This chart depicts the lives of key Islamic Scientists and related writers, from the 8th to the end of the 13th century. By placing each writer in a historical context, this will help us understand the influences and borrowing of ideas.

701 (died) - Khalid Ibn Yazeed - Alchemy
721 - Jabir Ibn Haiyan (Geber) - (Great Muslim Alchemist)
740 - Al-Asmai - (Zoology, Botany, Animal Husbandry)
780 - Al-Khwarizmi (Algorizm) - (Mathematics, Astronomy)
787 - Al Balkhi, Ja'Far Ibn Muhammas (Albumasar) - Astronomy, Fortune-telling
796 (died) - Al-Fazari,Ibrahim Ibn Habeeb - Astronomy, Translation
800 - Ibn Ishaq Al-Kindi - (Alkindus) - (Philosophy, Physics, Optics)
808 - Hunain Ibn Is'haq - Medicine, Translator
815 - Al-Dinawari, Abu-Hanifa Ahmed Ibn Dawood - Mathematics, Linguistics
836 - Thabit Ibn Qurrah (Thebit) - (Astronomy, Mechanics)
838 - Ali Ibn Rabban Al-Tabari - (Medicine, Mathematics)
852 - Al Battani ABU abdillah (Albategni) - Mathematics, Astronomy, Engineering
857 - Ibn MasawaihYou'hanna - Medicine
858 - Al-Battani (Albategnius) - (Astronomy, mathematics)
860 - Al-Farghani (Al-Fraganus) - (Astronomy, Civil Engineering)
884 - Al-Razi (Rhazes) - (Medicine, Ophthalmology, Chemistry)
870 - Al-Farabi (Al-Pharabius) - (Sociology, Logic, Science, Music)
900 - (died) - Abu Hamed Al-ustrulabi - Astronomy
903 - Al-Sufi (Azophi - (Astronomy)
908 - Thabit Ibn Qurrah - Medicine, Engineering

912 (died) - Al-Tamimi Muhammad Ibn Amyal (Attmimi) - Alchemy
923 (died) - Al-Nirizi, AlFadl Ibn Ahmed (wronge Altibrizi) - Mathematics, Astronomy
930 - Ibn Miskawayh, Ahmed Abuali - Medicine, Alchemy
932 - Ahmed Al-Tabari - Medicine
936 - Abu Al-Qasim Al-Zahravi (Albucasis) - (Surgery, Medicine)
940 - Muhammad Al-Buzjani - (Mathematics, Astronomy, Geometry)
950 - Al Majrett'ti Abu-alQasim - Astronomy, Alchemy, Mathematics
960 (died) - Ibn Wahshiyh, Abu Baker - Alchemy, Botany
965 - Ibn Al-Haitham (Alhazen) - Physics, Optics, Mathematics)
973 - Abu Raihan Al-Biruni - (Astronomy, Mathematics)
976 - Ibn Abil Ashath - Medicine
980 - Ibn Sina (Avicenna) - (Medicine, Philosophy, Mathematics)
983 - Ikhwan A-Safa (Assafa) - (Group of Muslim Scientists)
1019 - Al-Hasib Alkarji - Mathematics
1029 - Al-Zarqali (Arzachel) - Astronomy (Invented Astrolabe)
1044 - Omar Al-Khayyam - (Mathematics, Poetry)
1060 - (died) Ali Ibn Ridwan Abu'Hassan Ali - Medicine
1077 - Ibn Abi-Sadia Abul Qasim - Medicine
1090 - Ibn Zuhr (Avenzoar) - Surgery, Medicine
1095 - Ibn Bajah, Mohammed Ibn Yahya
1097 - Ibn Al-Baitar Diauddin (Bitar) - Botany, Medicine, Pharmacology
1099 - Al-Idrisi (Dreses) - Geography, World Map (First Globe)
1091 - Ibn Zuhr (Avenzoar) - (Surgery, Medicine)
1095 - Ibn Bajah, Mohammad Ibn Yahya (Avenpace) - Philosophy, Medicine
1099 - Al-Idrisi (Dreses) - (Geography -World Map, First Globe)
1100 - Ibn Tufayl Al-Qaysi - Philosophy, Medicine
1120 - (died) - Al-Tuhra-ee, Al-Husain Ibn Ali - Alchemy, Poem
1128 - Ibn Rushd (Averroe's) - Philosophy, Medicine
1135 - Ibn Maymun, Musa (Maimonides) - Medicine, Philosophy
1140 - Al-Badee Al-Ustralabi - Astronomy, Mathematics
1155 (died) - Abdel-al Rahman AlKhazin - Astronomy
1162 - Al Baghdadi, Abdellateef Muwaffaq - Medicine, Geography
1165 - Ibn A-Rumiyyah Abul'Abbas (Annabati) - Botany
1173 - Rasheed AlDeen Al-Suri - Botany
1184 - Al-Tifashi, Shihabud-Deen (Attifashi) - Metallurgy, Stones
1201 - Nasir Al-Din Al-Tusi - (Astronomy, Non-Euclidean Geometry)
1203 - Ibn Abi-Usaibi'ah, Muwaffaq Al-Din - Medicine
1204 (died) - Al-Bitruji (Alpetragius) - (Astronomy)
1213 - Ibn Al-Nafis Damishqui - (Anatomy)

1236 - Kutb Aldeen Al-Shirazi - Astronomy, Geography
1248 (died) - Ibn Al-Baitar - (Pharmacy, Botany)
1258 - Ibn Al-Banna (Al Murrakishi), Azdi - Medicine, Mathematics
1262 (died) - Al-Hassan Al-Murarakishi - Mathematics, Astronomy, Geography
1273 - Al-Fida (Abdulfeda) - (Astronomy, Geography)
1306 - Ibn Al-Shater Al Dimashqi - Astronomy, Mathematics
1320 (died) - Al Farisi Kamalud-deen Abul-Hassan - Astronomy, Physics
1341 (died) - Al-Jildaki, Muhammad Ibn Aidamer - Alchemy
1351 - Ibn Al-Majdi, Abu Abbas Ibn Tanbugha - Mathematics, Astronomy
1359 - Ibn Al-Magdi,Shihab-Udden Ibn Tanbugha - Mathematic, Astronomy

Based on the book "Introduction to the History of Science" by George Sarton (Sarton, 1975).

Appendix B

Human Development Report 2007 Data
Some selected Muslim Countries

HDI rank		Internet users (per 1,000 people) 1990	2005	Patents granted to residents (per million people) 2005	Receipts of royalties and license fees (US$ per person) 2005	Research and development expenditure (% of GDP) 2000-2005	Researchers in R&D (per million people) 1990-2005
High Human Development							
33	Kuwait	0	276	..	0.0	0.195154797264097	..
61	Saudi Arabia	0	70a	(.)	0.0	..	..
63	Malaysia	0	435	..	1.1	0.691491694591844	299
Medium Human Development							
86	Jordan	0	118a	..	..	..	1,927
88	Lebanon	0	196	..	0.0a	..	..
91	Tunisia	0	95	..	1.4	0.628970813184855	1,013
94	Iran (Islamic Republic of)	0	103	8	..	0.67	1,279
104	Algeria	0	58	1	..	..	..
107	Indonesia	0	73	..	1.2	5.33534879533951E-02	207
108	Syrian Arab Republic	0	58	2	..	..	29

112 Egypt	0	68	1	1.9	0.193268373691651	493
136 Pakistan	0	67	0	0.1	0.222311191620916	75
140 Bangladesh	0	3	..	(.)	0.620895375724091	51

Notes:
a. Data refer to 2004.
Source:
column 1: World Bank. 2007b. World Development Indicators 2007. CD-ROM. Washington, D.C.; aggregates calculated for HDRO by the World Bank.
column 2: World Bank. 2007b. World Development Indicators 2007. CD-ROM. Washington, D.C.; aggregates calculated for HDRO by the World Bank.
column 3: calculated on the basis of data on patents from WIPO (World Intellectual Property Organization). 2007. "Patents Granted by Office (1985-2005)." Geneva. [http://wipo.int/ipstats/en/statistics/]. Accessed May 2007 and data on population from UN (United Nations). 2007e. World Population Prospects 1950-2050: The 2006 Revision. Database. Department of Economic and Social Affairs, Population Division. New York. Accessed July 2007.
column 4: calculated on the basis of data on royalties and license fees from World Bank. 2007b. World Development Indicators 2007. CD-ROM. Washington, D.C and data on population from UN (United Nations). 2007e. World Population Prospects 1950-2050: The 2006 Revision. Database. Department of Economic and Social Affairs, Population Division. New York. Accessed July 2007.
column 5: World Bank. 2007b. World Development Indicators 2007. CD-ROM. Washington, D.C.; aggregates calculated for HDRO by the World Bank.
column 6: World Bank. 2007b. World Development Indicators 2007. CD-ROM. Washington, D.C.; aggregates calculated for HDRO by the World Bank.

Human Development Report 2007 Data

Some selected Technologically Advanced Countries

HDI rank	Internet users (per 1,000 people)		Patents granted to residents (per million people)	Receipts of royalties and license fees (US$ per person)	Research and development expenditure (% of GDP)	Researchers in R&D (per million people)
	1990	2005	2005	2005	2000-2005	1990-2005
High Human Development						
3 Australia	6	698	31	25.0	1.70497399344551	3,759
4 Canada	4	520	35	107.6	1.93	3,597
8 Japan	(.)	668	857	138.0	3.14540285993759	5,287

9 Netherlands	3	739	110	236.8	1.84822798236219	2,482
10 France	1	430	155	97.1	2.16	3,213
12 United States	8	630a	244	191.5	2.68	4,605
16 United Kingdom	1	473	62	220.8	1.89395132900524	2,706
17 Belgium	(.)	458	51	106.5	1.90264687952738	3,065
21 Hong Kong, China (SAR)	0	508	5	31.2a	0.60475557722662	1,564
22 Germany	1	455	158	82.6	2.49	3,261
23 Israel	1	470a	48	91.2	4.46	..
26 Korea (Republic of)	(.)	684	1,113	38.2	2.64348645642938	3,187
47 Croatia	0	327	4	16.1	1.14416234181243	1,296
70 Brazil	0	195	1	0.5	0.980334335350253	344

Notes:
a. Data refer to 2004.
Source:
column 1: World Bank. 2007b. World Development Indicators 2007. CD-ROM. Washington, D.C.; aggregates calculated for HDRO by the World Bank.
column 2: World Bank. 2007b. World Development Indicators 2007. CD-ROM. Washington, D.C.; aggregates calculated for HDRO by the World Bank.
column 3: calculated on the basis of data on patents from WIPO (World Intellectual Property Organization). 2007. "Patents Granted by Office (1985-2005)." Geneva. [http://wipo.int/ipstats/en/statistics/]. Accessed May 2007 and data on population from UN (United Nations). 2007e. World Population Prospects 1950-2050: The 2006 Revision. Database. Department of Economic and Social Affairs, Population Division. New York. Accessed July 2007.
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