

SCIENCE IN THE MODERN MUSLIM WORLD¹

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Between the 9th and 13th centuries Islamic civilization had made major original contributions to the development of pre-modern science, and had transmitted Greek learning to Europe through a major translation effort². However, the emergence of modern science and crystallization of the scientific method really occurred in the massive revolution which began in 16th century Europe, and which left in its wake a world transformed both intellectually and physically. Traditional belief systems were challenged by the paradigm of a new culture based on experimentation, prediction, quantification and control. Power relations between countries became increasingly defined by their mastery of technology, ultimately leading to the colonization by European countries of much of the Islamic world. For many traditional societies, and some Islamic societies in particular, acceptance of the new scientific paradigm was - and in some cases still is - problematic both because of its association with colonialism and for cultural reasons. Combined with the global inequities in the distribution of power and wealth, this may be an important factor in explaining the disproportionately small representation in science and technology by Muslims, who constitute about 20% of the world's population.

EARLY BEGINNINGS

The introduction of post-renaissance science, technology, and thought into Islamic societies was pioneered by several outstanding individuals in the 19th century. In Egypt,

¹ This is a preliminary version of an article to be published in the **Encyclopedia Of The Modern Islamic World**, Oxford University Press.

² A detailed account of this can be found in George Sarton's work , Introduction To the History Of Science, Vol. I&II, New York, 1975.

following the Napoleonic occupation, Muhammad Ali seized state power and ruled from 1805 through 1848, during which period he made bold attempts to transfer French and British technology into the country, relying principally on European expatriates. He introduced the first printing press - a device initially condemned by some of the ulema as having a belt of pigs skin. But this resistance was overcome, and the Bulaq press in Cairo published 81 Arabic books on science between 1821 and 1850. Technology for irrigation, textile manufacturing, surveying, prospecting and mining for coal and iron, and military hardware received high priority. Major earth moving and civil engineering projects were embarked upon. Even more significantly, technical schools with foreign teachers were established with the aim of generating manpower. More than 400 students were sent to Europe to study various branches of science, including military tactics. However, the success of Muhammad Ali's industrialization policies was mixed. The quality of domestically produced products, such as textiles, was poor. Technical schools provided insufficient exposure to theoretical science, and did not succeed in creating a base of technicians or engineers of sufficiently high calibre. The reasons for this have been debated³. After Mohammed Ali's death in 1849, these schools were closed down under the rule of Khedive Abbas and Khedive Sa'id, and the scientific momentum ground to a halt. Among other Arab rulers, Sultan Sa'id bin Sultan of Oman (1806-1856) is notable for his interest in acquiring European technology. He made numerous attempts to have sugar refineries installed in Zanzibar, an Omani possession. He also made unsuccessful attempts at ship building. Emir Abdel Kader of Algeria, whose rule extended from 1832 to 1847, engaged various experts to build small ordnance factories and appears to have understood the importance of technology for progress.

The Turkish Ottomans had established an extensive and magnificent empire in the 16th century and had recognized the utility of military technology, particularly cannons, which they readily borrowed from the West. But there were strong religious taboos which, for example, prevented the use of the printing press or of public clocks. Travelers to Turkey in this period remarked on the lack of interest in matters of science and learning. Sweeping changes in civil administration and education came with Sultan Selim III (1761-1808), who was the last and the most radical of the Ottoman reformers. Selim established a new military corps armed and organized in the most modern techniques of warfare in Europe. Gun founding was introduced, printing presses were set up, and the works of Western authors were translated into Turkish. To sustain the modern army the

³ See, for example, A.B. Zahlan in "A History Of Technology In The Arab World, 1800-1977"

subjects of algebra, trigonometry, mechanics, ballistics, and metallurgy were introduced into the teaching curriculum. Like Muhammad Ali, Selim III had no choice but to import teachers from Europe for these subjects. The importance of theoretical science as a basis for continued development appears not to have been recognized. The major impetus to scientific and industrial development came after the revolution brought about by Mustafa Kemal Atatürk (1881-1938) in 1924. Prior to this, education had been limited to the cities and controlled by religious authorities. But after the secularization of Turkey, the control was taken over by the state and the curricula revised to include modern science, mathematics, world history, etc. Among Muslim countries, Turkey is today the most advanced in scientific research and in terms of the quality of its universities.

On the Indian subcontinent modern scientific ideas and techniques came in the wake of the English conquest. In the decades preceding this, the rule of the Moghuls had produced a civilization known for impressive architecture, literature, and poetry but with few achievements in the realm of knowledge. The Moghuls did not set up any universities or centres of learning. Some transmission of Western technology had taken place in the reign of Emperor Akbar (1542-1605), when Europeans had come as traders. Notably, ships of large tonnage and shapes similar to English ones were built. But these lacked compasses, gimbals, navigational charts, etc. Reading glasses were greatly admired by Akbar, but they appear to have been imported from France. After the banishment of the last Moghul emperor Bahadur Shah Zafar in 1857, the English consolidated their rule and later introduced modern education. A combination of hurt, pride, defiance, and conservatism led Muslims to resist Western learning. Consequently, Muslims were at a substantial disadvantage relative to Hindus; it is recorded, for example, that between 1876-7 and 1885-6, 51 Muslims and 1,338 Hindus took the B.A degree at Calcutta. In 1870 only 2 Muslims, both of whom failed, sat for the B.A while, in the same year, 151 Hindus took the examination of whom 56 received the degree.

The resistance of Muslims of the subcontinent to modern ideas motivated Syed Ahmad Khan (1817-1898) into becoming a forceful proponent of modern science and thought. He was convinced that the subjugation of Muslims to the West was a result of their scientific backwardness, and that this in turn was a consequence of the dominance of superstitious beliefs and rejection of maaqulat (reason) in favour of blind obedience to manqulat (tradition). He therefore set about the monumental task of reinterpreting Muslim theology, making it compatible with post-Renaissance Western humanistic and scientific ideas. Syed Ahmad Khan founded the Aligarh Muslim University, which

provided Muslims of the subcontinent a unique opportunity for higher education. His articles in the periodical Tahzib-ul-Akhlaq, which included translations and explanations of scientific tracts as well as his interpretations of religious issues, were highly influential among upper class Muslims. To maintain consistency with science, he argued that miracles - such as Noah's Flood - must be understood in allegorical rather than literal terms. This position brought Syed Ahmad Khan widespread condemnation and numerous fatwas against his life.

Syed Jamaluddin Afghani (1838-1897), also a supporter of Western science and modern ideas, but an implacable opponent of Syed Ahmad Khan, was a determined anti-imperialist who inspired Muslims in Turkey, Egypt, Iran, and India. Like his mentor Mohammad Abduh (1849-1905), Afghani held that there was no contradiction between Islam and science, and that Islam encouraged rational thought and discouraged blind imitation. In 1870, because of pressure from the clergy, Afghani was expelled from Istanbul for advocating the setting up of a Darul-Funun, a new university devoted to the teaching of modern science. He is known for his vitriolic criticism of those *ulema* who opposed modern ideas and science.

Modernization and the introduction of science have inevitably brought about the issue of having to choose between traditional and modern education for Muslims, or perhaps devising an acceptable synthesis. Traditional Islamic education, with its emphasis on teaching of the Quran and Sunnah and on perfect memorization, had remained essentially unchanged since the Nizammiyah curriculum was devised under the rule of the Sultan Nizam-ul-Mulk in the 11th century. Ibn Khaldun, in a comparative study of education in Muslim lands of the 14th century, pointed out that only in Muslim Spain and Persia were subjects such as poetry, grammar, and arithmetic included in the syllabi. Elsewhere, subjects unrelated to the Qu'ran were regarded as too secular to teach to children. The Nizammiyah curriculum was faithfully passed on to subsequent generations and also adopted in unchanged form in Mughal India, until somewhat modified by Shah Waliullah (1703-?) to include arithmetic and logic. However, al-Azhar University in Cairo did have some scientific subjects in its teaching syllabus, including mathematics and astronomy, even prior to the Napoleonic invasion. These largely reflected knowledge which had long since been superseded. The astronomy taught, for example, was based on a Ptolemaic model requiring the sun to go around the earth. Thus, it was a prime goal of Muslim modernists to effect the transfer of Western models of universities and schools into their societies. The spread of science teaching in several Arab countries, such as

Egypt, Syria, Iraq, and Lebanon, and on the Indian subcontinent, was greatly aided by Christian missionary efforts. Although their purpose was primarily evangelical, they brought considerable intellectual stimulus coming from new developments in the West. The first Western scientific institutions in the Arab world were the Syrian Protestant College and the Jesuit St. Joseph's College, both in Beirut.

SCIENTIFIC ACHIEVEMENTS

According to an ISESCO (Islamic Educational and Scientific Organization) report of 1986, there are 628 science and technology research institutes and centres in Muslim countries out of which 173 are engaged in agricultural research. There are 4 desert institutes, 58 centres of medical research, 47 for veterinary sciences, 45 for energy and 44 for industrial research. There are 9 centres for nuclear studies, 8 for space research, 7 for biotechnology, 9 for oceanography and 4 in computer sciences. Pakistan has the highest number of research institutes and centres (142), followed by Indonesia (70), Turkey (58) and Egypt (35). However, the quality of these institutions is generally below those in the advanced countries. Recent, and reasonably complete, scientometric studies of Muslim scientific productivity appear not to be available. In 1976 a study by Moravcsik counted 352,000 scientific authors, of which only 3,300 were from Muslim countries. A small scale study conducted in 1989 showed Muslim scientific authorship of physics papers to be 46 out of a sample of 4,168, 53 out of 5,050 in mathematics, and 128 out of 5,375 in chemistry. From publications quoted in the scientific citation index of 1988 it appears that, on a relative scale, Egypt (17) and Turkey (10.5) are relatively advanced among Muslim countries, although much below the level of Israel (72) and India (90).

According to a 1987 report on the status of scientific research in Arab countries, authored by the Federation of Arab Scientific Research Councils, there are 82 universities and about 250 independent research institutions in the Arab world. The total number of academic staff is about 52,000 of which about 55% are Ph.D's. About 59% of all researchers are in Egypt. Expenditure on scientific research ranges from 0.02% to 0.5% of the GNP, a percentage which is very low compared to developed countries. The report quotes a survey showing that the number of published papers in scientific journals is about 20% of those published in India, 4% of USSR, and less than 1% of the USA. The number of research papers per researcher per year ranges between 0.1 and 0.6. Reasons

for this low productivity are stated to be the lack of funds, excessive teaching loads of faculty, lack of promotion incentives, etc.

Although the productivity of Muslim scientists residing in their own countries is low, Muslims living abroad in the advanced countries are relatively much more productive and several have been credited with important scientific discoveries. Mohammed Abdus Salam, together with Steven Weinberg and Sheldon Glashow, received the Nobel Prize for physics in 1979 for fundamental work which unified the weak and electromagnetic interactions. However, it should be noted that Salam's Ahmeddiya sect, while it continues to claim adherence to Islam, was officially excommunicated by an act of the Pakistani parliament in 1974. Salam has been by far the most articulate and effective proponent of Muslim scientific development and is the founder-director of the International Centre for Theoretical Physics, an organization which has played an important role in stimulating scientific research in developing countries by inviting thousands of researchers to participate in research conferences and workshops in Trieste, Italy. The Third World Academy of Sciences, an offshoot of the ICTP, is also headed by Salam and receives some financial support by Muslim countries.

The global diffusion of modern technology has profoundly altered life-styles in Muslim countries and has become an inseparable part of modern existence. It is not, however, easy to decide on the status of a country in the field of science and technology in a simple quantitative manner. But one important indicator of the level of scientific-technological development of a country is the extent to which industry and manufacturing are part of its economy. This, in turn, is estimated by the "value added" in manufacturing, which includes machinery and transport equipment, chemicals, textiles, etc. Data on "value added" is published yearly in the Development Report of the World Bank, which the reader may consult for estimating the relative levels of progress of individual countries. Indonesia and Malaysia are among the fastest growing economies of the world, partly because of their success in attracting foreign investment, and partly because of high investments in human resource development. There has been a steady rise in "value added" for most Muslim countries but absolute levels are still low: In 1983, of 46 Muslim states, only 24 produced cement, 11 produced sugar, 5 had heavy engineering industries, 6 produced textiles, and 5 produced light armaments. By and large, Muslim states are consumers of technology and producers of raw materials, oil being the most important one of these.

In the nuclear area, considered as the domain of medium-high technology, Pakistan has relatively the most advanced programme among Muslim countries. It has one Canadian supplied power reactor with a second Chinese supplied one currently (1994) in the process of installation, and an extensive uranium enrichment programme using centrifugal technology derived from Holland and Belgium. It is the only Muslim country which has a nuclear weapons capability and, as of 1993, is thought to possess sufficient material to make between 6-12 Hiroshima size devices. Iraq, prior to the destruction of its nuclear installations after the Gulf War, had reached a point where it was an estimated 2-3 years away from achieving nuclear capability. Iran and Egypt have small, energy oriented nuclear programmes as well but appear to have no serious intentions of acquiring nuclear weapons.

REACTIONS TO SCIENCE

The relatively slow growth of science and modern ideas in most Muslim countries has elicited three types of responses from Muslims. One extreme reaction, exemplified by Syed Qutb of Egypt and Syed Abul Ala Maudoodi of Pakistan, has been to claim that lack of scientific progress is not particularly regrettable because modern science is guided by no moral values, but naked materialism and arrogance. Its emphasis upon constant change militates against the immutable and constant values of Islam, and its claims to high achievement and total dependence on human reason amount to man worship. Therefore, according to this view, scientific development is not possible - and not even desirable - in an Islamic society. A second reaction has been to reinterpret the Faith in order to reconcile the demands of modern science and civilization with the teachings and traditions of Islam. This school of thought has a historical tradition with roots going back to the rationalist Mutazilla movement of the 9th century, and the work of Ibn Rushd, particularly his book Tahafut-al-Tahafut in which he refuted the anti-rationalism of Imam al-Ghazali. In this "reconstructionist" tradition, it is argued that the word of God cannot be wrong, but also that the truths of science are manifest and real. Therefore the only issue is to arrive at suitable interpretations of the Qu'ran, through careful etymological examination, wherever there is an apparent conflict between the revealed truth and physical reality. It is held that Islam in the days of the Prophet and the Khilafa-i-Rashida was revolutionary, progressive, and rational and that the subsequent slide into stultifying rigidity was due to the triumph of taqlid (tradition) over ijtihad (innovation). Mohammed Abduh, Rashid Rida, and Syed Ahmad Khan were the leading proponents of this point of

view. A third attitude has been to treat requirements of science and modernity as essentially unrelated to the direct concerns of religion and faith. Such persons are satisfied with the vague belief that Islam and science are not in conflict, but are disinclined to examine such issues too closely. From this point of view, the preoccupation of those who search for Qur'anic justifications of the facts of modern science appears as redundant and arcane. It is probably fair to say that this is the majority point of view among Muslims today.

It is interesting to examine Muslim attitudes towards major developments in science, of which Darwin's theory of evolution provides the most contentious example. The first major debate, which pitted traditionalist Muslim and Christian Arabs on the one side against rationalists and radicals on the other, was initiated in 1884 following the publication of a work in Arabic by Shibli Shumayyil (1853-1917) favouring Darwinism. Expectedly, religious conservatives denounced Darwin's theory as amounting to the denial of God and a refutation of the Quranic and biblical theories of creation. Even Jamaluddin Afghani, otherwise a powerful proponent of science, derided Darwinism - although it appears that he had not understood, or even read, any of Darwin's work. A few Muslims, such as the writer Ismail Mazhar (1891-1962), did make serious efforts to understand Darwinian evolution and asserted the need to reinterpret Islamic theology in the light of established facts. Others, such as the theologian Hussein al-Jisr (1845-1909), sought to reconcile elements of Darwin's work with Islam.⁴ In the contemporary Muslim world, attitudes towards Darwinism are mixed. Teaching of the theory of evolution is allowed in Turkey, Egypt, Iraq, Iran, Indonesia, and several other countries. However, it was removed from the syllabus in Pakistan in the regime of General Zia-ul-Haq, and is expressly forbidden in Saudi Arabia and Sudan.

It is harder to find specific Muslim responses to other major scientific developments such as Einstein's Theory of Relativity, quantum mechanics, big-bang cosmology, or chaos. Following the standard criticisms common earlier on in this century in the West - wherein Einstein's Relativity was taken to imply moral relativism and quantum mechanical uncertainty as an unacceptable limitation on the power of God - a few Muslim writers have continued to argue that these major ideas of science are in

⁴ A comprehensive account of this historical debate may be found in "Western Science In The Arab World - The Impact Of Darwinism, 1860-1930" by Adel A. Ziadat, London, 1986. The author concludes that an author's religion - whether Muslim or Christian - was of secondary importance in this debate. Rather, it was largely a debate between religious men on the one hand and secularists on the other.

conflict with Quranic teachings. However, these seem to be isolated examples, and the majority attitude has been to ignore such issues or to passively accept them. Unlike the vigorous science vs religion debates in post-scientific revolution Europe, there seems to be little discussion on the philosophical implications of modern scientific issues in Muslim countries, with Turkey and Iran being partial exceptions. The reason for this relatively low level interest may be the increasing specialization of science and the difficulty of translating its ideas into ordinary language, as well as the reluctance of the ulema to be drawn into new fields. However, some time-honoured issues continue to be routinely debated and commented upon. One such issue is whether the new moon must be visually sighted, or whether its position can be predicted in advance with modern astronomical techniques. This becomes important and contentious especially around the time of Eid-ul-Fitr. In Pakistan, a Ruet-i-Hilal committee has been formed by the government to make final decisions on this matter. Weather prediction is an issue on which there has been a considerable softening of the traditionally hard position - that Allah alone knows and decides if and when it will rain, and that He has prescribed the namaz-i-istisqa (prayer for rain) so that believers may supplicate him. Presently all Muslim countries maintain some form of meteorological department and provide weather information. Whereas orthodox ulema continue to maintain their position against the dissection of cadavers for medical training, blood transfusions, and organ transplants, this is essentially disregarded almost everywhere in Muslim countries now.

In recent years, the applications, methodology and epistemology of modern science have been severely criticized by growing numbers of Muslim conservatives. At one level, in close similarity with the radical critiques of science by the German "Greens" as well as European marxists and anarchists, it is argued that the development and application of a supposedly value-free science is the prime cause of the myriad problems faced by the world today - weapons of mass destruction, environmental degradation, global inequities in the distribution of wealth and power, alienation of the individual, etc. Others go a step beyond this and reject the validity of the scientific method as well as the notion of science as knowledge, believing that the goals and techniques of modern science - which are considered distinct from those of medieval age science - will inevitably damage the fabric of Islam. Knowledge for the sake of knowledge is declared to be a dangerous and illegitimate goal, and the only form of legitimate knowledge is that which leads to a greater understanding of the Divine. The most articulate representation of this point of view is by the Iranian born scholar Syed Hossein Nasr who also argues that the word ilm, whose pursuit is a religious duty, has been wilfully distorted into

meaning science and secular learning by Muslim modernists in an effort to make science more acceptable in Islamic societies.

The reaction of Muslim orthodoxy to the teaching of modern science in schools has been to demand basic changes. These include some or all of the following: introduction to all scientific facts by reference to Allah, dilution of the cause-and-effect relation to accommodate the Divine Will, rewriting of all science books by people of sound Islamic beliefs, highlighting of the former Muslim supremacy in science, and removal of names associated with specific physical laws (eg. Boyle's Law, Einstein's Theory, etc.). It should be noted, however, that the Iranian clergy has allowed science taught in Iranian schools to maintain its secular character.

ISLAMIC SCIENCE

Exponents of "Islamic Science" argue that it offers an Islamic alternative to the challenge of modern Western science, which they consider as reductionist and incapable of accommodating Islamic beliefs. Individual proposals for creating this alternative science have emerged in large numbers since the 1970's. However, given the absence of a centralized religious authority - an "Islamic Church" - the validity of these proposals cannot be clearly certified from the religious point of view. One fairly common definition of "Islamic science" is that every scientific fact and phenomena known today was anticipated 1,400 years ago and that all scientific predictions can and must be based upon study of the Qur'an. This has been the concern of dozens of conferences in numerous Muslim countries, including Egypt, Pakistan, Malaysia and Saudi Arabia. A popular author who advocates this version of Islamic science is Maurice Bucaille. A French surgeon who turned into a spiritualist, Bucaille's major book is "The Bible, The Qur'an, And Science". This book, which seeks to establish that the Qur'an correctly anticipated all major discoveries of science while the Bible was flawed in places, has been translated into several languages and read widely in Muslim countries.

Another opinion is that Islamic science is that which is based on Islamic values and beliefs such as tawheed (unity of God), ibadah (worship), khilafah (trusteeship), and which stands for the rejection of zalim (tyrannical) science as well as science for the sake of curiosity. Revelation rather than reason ought to be ultimate guide to valid knowledge. Syed Hossein Nasr demands that: "a truly Islamic science cannot but derive

ultimately from the intellect which is Divine and not human reason.....the seat of the intellect is the heart rather than the head, and reason is no more than its reflection upon the mental plane". He provides no further clues of how the new science should be organized. Other Muslim authors insist that the study of natural disasters, which constitutes Islamic environmental science, must begin with trying to understand God's will because earthquakes, volcanic eruptions, floods, etc. are events under His direct control and part of a grand systems scheme. One of the most articulate advocates of the Islamization of knowledge, including science, was the late Isma'il Al Faruqi.

One should distinguish science practiced by Muslims - whether in the present epoch or in the "Golden Age" of Islamic civilization - from "Islamic science", which is supposed to reflect specifically Islamic characteristics. Whether an Islamic science of the physical world is a meaningful notion or concept can be challenged on at least three grounds. First, decades of efforts to create a specifically Islamic science have failed. The fact is that Islamic science has not led to the building of even a single new machine or instrument, the design of a new experiment, or the discovery of a new and testable fact. Only post-facto explanations have been provided, never a prediction. Second, specifying a set of moral and theological principles - no matter how elevated - does not permit one to build a new science from scratch. There are numerous examples of scientists subscribing to very different philosophical assumptions and having very different emotional and psychological dispositions, who have arrived at very similar results in their scientific investigations. Although a scientist may be inspired towards making a particular discovery as a consequence of his belief, his claims of discovery must be validated by a system of science which relies on experimentation and testing as its basis. Third, there has never existed, and still does not exist, a definition of Islamic science which is acceptable to Muslims universally. Many of the great Muslim scholars of medieval times, including Al-Kindi, Al-Razi, Ibn-Sina, and Ibn-Rushd, suffered persecution at the hands of the orthodoxy on account of their non-traditional religious and spiritual beliefs. The sectarian divisions within Muslims today would be reflected in any endeavour to establish a common set of rules. It is also worthy of note that all suggestions of creating a new epistemology of science based on ideological or moral principles have failed to be of little value because they are far too vague and ill-defined.

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