

## **Science and religion as concepts: a history**

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### **Abstract**

I will discuss the acquisition and transmission of (what we now call scientific) knowledge through history and among cultures, with emphasis on early periods: India, Persia, Greek, early Christian and early Islamic. Themes will be the stages of cultures which transmit such knowledge and those which receive it, and the tensions between knowledge from “science” (observation, deduction, prediction) and knowledge from revealed religion. These are similar in all cultures, reappearing as new kinds of knowledge in tension with different theologies. I will contend that there is really nothing new under the sun re. science vs. religion. Science did not begin with the Renaissance in Europe. Similar tensions and resulting cultural/political conflicts have flowed through history and cultures for millennia. In particular, the belief that it is all a recent civilizational conflict between Judeo-Christian European scientific mentality and an opposing theocratic Islamic mentality has no historical basis. Of course many non-Islamic as well as Islamic cultures are rife with theocratic mentalities these days—but my purpose here is to show how the same tensions flow, transmit, and reappear throughout history. Karen Armstrong and Amartya Sen, among others, provide support and similar views.

### **Preamble**

My emphasis will be on science and religion in Christianity and Islam, on the history as well as the present-day situation, and on the Muslim world and the West. I will start with the present day, to try to establish the political context which has probably brought about an Oxford Round Table on this subject. It will have little to do with science. That will follow.

### **Islam and Muslim countries facing the West—jihad, clash of civilizations, the role of religion, Israel & Palestine, etc.**

So much is driven by western foreign policy and is given an Islamic gloss after the fact. Huntington 1996 (of “clash of civilizations” fame) says otherwise; but Kinzer (2003, 2007), Lewis (2002), Meddeb (2003), Ramadan (2003), Sen (2006) and many others support this. Re. the Middle East especially the Israeli-Palestinian conflict it is widely agreed that muslim anger and creation of the terrorist form of jihad is driven by the colonial history and by western, especially US, foreign policy (Albright 2006, Ali 2002, Armstrong 2001b, Khalidi 2005, 2006, Neumann 2005, Said 1995, 2002). Rightly or wrongly, resentment is still great of the western-backed establishment of Israel on top of 700,000 Palestinian Arabs who had to leave their land. The typical western attitude is that it was sad, for both the Jews during and after the Second World War and for the dispossessed Palestinians, but that it’s in the past and everyone ought to just get on with it. Probably that is close to my attitude because it is difficult to see any other way out. But the problem is that it isn’t really in the past. The Palestinian population has grown since 1948 to more than 4 million Palestinians living in the Israeli-occupied West Bank and Gaza, mostly living in squalor and without any real political control of their lives. Four million Palestinians today from 700,000 in 1948 seems like a lot but in fact if one takes the 2006 rate of population increase of 3.71% per year and applies it over the 60 years since 1948, there should be twice that many Palestinians today. Of course many have given up and migrated, mostly to western countries. Edward Said’s family was a case in point. As Palestinian Christians they illustrate the reality that there were many Christian as well as Muslim Palestinians dispossessed by the creation of Israel, and also the reality that non-muslims have migrated in disproportionate numbers so that an indirect effect has been to reduce the Christian (and Jewish outside of Israel) presence in the Middle East. Western foreign policy has caused that.

Thus the consequences remain after 60 years and especially for Muslims it is difficult to say “It’s the past, let’s forget the wounds, let the anger go, and just get on with it”. I can understand that too. Perhaps a real Palestinian state, contiguous and functional and with all the rights of a nation (Oz 1994; Khalidi 1997, 2008; Quigley 2005) , would change things, but with Israel blocking that and the US backing Israel “right or wrong”, it is hard to see it on the horizon. The Muslim world is very aware of how things still are and why they don’t change—so the anger remains. In the West, especially in the US, there is little awareness of this history and these causes of Muslim resentment and anger. After 9/11 any American who said maybe we should investigate why these young men would carry out such a murderous and suicidal act, which was clearly against the precepts of their religion on several grounds, was shouted down. Rudy Giuliani the then mayor of New York was typical, saying that there could be no reason for such a heinous act, so even talking about there being one was unpatriotic and treasonous. It’s odd - the British dealt for many years with IRA terrorist bombings without resorting to such silly logic, and in the end they reached a peaceful settlement in Northern Ireland. The US often seems naive, not working in its own long-term best interests, or even of Israel’s. It is interesting that it is much easier to discuss Middle East issues including the Israeli-Palestinian conflict in Israel, including recognizing even if disagreeing with Palestinian viewpoints, than it is in the US. Read the newspaper Haaretz online for example, or read books by the Israeli authors Kimmerling (2003a, 2003b) and Oz (1994, 2006). In the preface to his 1994 book Amos Oz remarks that “... Israel is the only homeland of the Israelis...[but] I regard Palestine as the legitimate and rightful homeland of the Palestinians. As it seems that Israelis and Palestinians cannot share their homeland, it must be divided between them. ...these pages were written by an Israeli who fought for his country and who loves it, even during...times when he was unable to like it. ...I have often felt that my country will survive and prosper only if it does right.” Ironically these views are similar to those of Palestinian-ancestry New York-born Rashid Khalidi (2008), the Edward Said Professor of Arab Studies and Director of the Middle East Institute at Columbia University, who has been called a terrorist by some in the US pro-Israel lobby (and by John McCain’s presidential campaign). In the US, criticism of Israel (or of the US itself), even if implied, is politically incorrect and fiercely attacked. Just think of the abuse that former US President and Nobel Peace Prize Winner Jimmy Carter took for his very even-handed 2007 book “*Palestine: Peace Not Apartheid*”, or that Michelle Obama took when she said (in a speech in Wisconsin Feb 8 2008) “For the first time in my adult lifetime I am proud of my country”, or that Mearsheimer and Walt took for their 2008 book “*The Israel Lobby and US Foreign Policy*”. The issue here is not whether they were right or wrong, but rather that some things can’t be said.

It should be remembered that Jews and Muslims have traditionally co-existed rather well, in fact much better than Jews and Christian Europeans. The Crusaders plundered both Jews and eastern orthodox Christians as they traveled to the Holy Land to do the same to Muslims (Armstrong 2001a). In the Islamic empire Jews were protected “Peoples of the Book” and many rose to high positions. Islamic Spain is only one example (Lane-Poole 2001, Lowney 2005). After the Christian “Reconquista” and the start of the Inquisition, most Spanish Jews fled to Muslim countries, for example to the Ottoman Empire, for safety. Some went to tolerant European countries like Holland, but there were few such places in western Europe. It is certainly arguable that present-day Muslim anger with Jews mostly has to do with Israel and the Palestinians, and not to do with Jews *per se*. Similarly Muslim anger with the Christian West mostly has to do with Western foreign policy and its effects on them. The historical evidence strongly suggests that this is so.

In fact most Palestinians (and most Muslims world-wide) are fairly secular in their approach to politics and nationalism. See Esposito and Megahed (2008). The Islamic rhetoric is usually a superficial “add-on”, similar to the American religious right’s rhetoric (and too often the rhetoric of the political leaders chasing their votes) which cloaks the issues that really drive most Americans.

Lord Arthur Balfour of the 1917 Balfour declaration said, regarding the rights of existing non-Jewish communities in Palestine, that “Zionism is rooted in age-long traditions, in present needs, in future hopes of far profounder import than the desires and prejudices of the 700,000 Arabs who now inhabit the ancient land.” When cautioned “Let us not...tell the Moslem what he ought to think”, Balfour replied “I am quite unable to see why heaven or any other power should object to our telling the Moslem what he ought to think.” Around the end of the Second World War, after the extent of the Holocaust became obvious to everybody, Ibn Saud argued to President Franklin Roosevelt that “Amends should be made by the criminal, not by the innocent bystander. What injury have the Arabs done to the Jews of Europe? It is the Christian Germans who stole their homes and lives.” President Truman is said to have remarked that there were many Jews but few Arabs among his constituents.

The point I am making here is that we are in a political world where most of the world-wide Muslim Ummah, and probably every Muslim in the Middle East, is aware of the relevant history of Islam and of the West’s reaction to it, and more recently of Palestine and Israel—but most Americans are not. This is as true of ignorance of the Islamic civilization’s contributions to Western science as it is of the interactions between Islam and the West since the European Renaissance. It isn’t that the US is on a crusade against Islam and wants to destroy it, or even that Muslims think so. The problem is that the US domestic political dynamic operates on a general ignorance of this history, and of foreign history, cultures, religion and ethics in general, so that in the end the policies of the one remaining world superpower are driven by its domestic economic issues (e.g. keep the price of petrol low and US-based multinationals prosperous), sometimes with fundamentalist religious rationales such as using the Book of Revelations to justify an “Israel Right or Wrong” foreign policy. Ignorance and bias reaches academic and professional levels as well (see Neumann 2005 on Dershowitz 2004, and Said 1997, 2003). Said’s book “*Orientalism*” has been controversial since it was first published in 1978; the 2003 edition is cited here. Winder’s 1981 review of *Orientalism* is worth reading, as is the more general “essential guide” to Said’s published work in general (including *Orientalism*) by Ashcroft and Ahluwalia (2001).

The reality is that the US doesn’t care one way or the other if the pursuit of its politically driven priorities destroy Islam, or keep nations in the Muslim world from developing democracy and economic prosperity and political independence. Unfortunately pursuit of the real US concerns indirectly has the same effect. And Muslims do see that reality. It is the hypocrisy that drives most Muslims (and Palestinians in particular) crazy. In vote after vote in the UN General Assembly it is only the US and one or two other countries of the size and stature of Nahru who vote against resolutions supporting the Palestinians and mildly criticizing Israel, and in the Security Council such resolutions routinely receive a US veto, but most Americans don’t even know that this happens, or if they do it is dismissed with anti-UN propaganda, as being anti-Semitic or anti-American - not as reflecting overwhelming world opinion with the US being the odd man out. Just stating these facts would be very politically incorrect, and for a politician

fatal. The US says it wants democracy, but when the world sees the US react to Hamas winning a West Bank election or Hezbollah participating in the democratic process in Lebanon and doing well, it sees that an acceptable democracy is one in which only US-approved parties should participate, or at least be allowed to win. The US backs strongmen who it thinks are the best potential clients, ones who won't interfere with American trade and business, will provide the resources which the US disproportionately consumes, and will allow a military presence or at least co-operate militarily. The hypocrisy shows when it does this with someone like Saddam Hussein or Manuel Noriega and then when they get out of US control turns around and paints them as villains. The US invaded and overthrew Hussein's quite secular regime on false grounds (links with Al-Qaeda, weapons of mass destruction), created a ferment of battling religious factions and a breeder of extremists, then labeled it as a war on Islamic terrorists. In Iran the US overthrew Mohammed Mossadegh's democratically elected secular government in 1953 in order to secure Iran's oil, and was surprised when in 1979 Ayatollah Khomeini swept into power (Kinzer 2003). Of course most Americans know nothing about what the US did to Iran in the 1950s.

Does the US think that just because Americans are largely ignorant of and disinterested in the rest of the world, that people in other nations don't remember what the US does and evaluate what the US says in relation to what it has done, that what the US has done doesn't have consequences (Kinzer 2007), what Johnson (2004) calls "blowback"? Immediately after 9/11 sympathy and support for the US in majority-Muslim countries was high, but after two years of the "war on terrorism" and of the US invading Muslim countries to impose a US-tilting version of democracy on them, it had dramatically dropped. For example a report by the US State Department Office of Research, as reported by Pew Research in 2006, indicated that in Indonesia favourable opinions of the US were 75% in 1999-2000, 61% in 2002, and 15% in 2003. In Turkey the figures are 52, 30 and 15%. In Jordan the available data are for 2002 (25%) and 2003 (1%). To be sure, it is not just a Muslim judgement. In Great Britain, the US's major partner in Iraq, the figures for 1999-2000 to 2004 are 83, 75, 70 and 58%. For France they are 62, 63, 43 and 37%, and for Germany 78, 61, 45 and 38%. Whether it is a correct judgement or not, it is fair to say that much of the world, both Muslim and non-Muslim, disapproves of US foreign policy during the post-9/11 years. Much support and sympathy immediately after 9/11 has been lost. Albright (2006) comments that "Many people, and not only in Muslim societies, believe that America's real aims are to control oil, defeat Muslims, advance the interests of Israel, and dominate the world - just as Al Qaeda has alleged."

Most Americans would object to that, but then most Americans believe that the War of 1812 was started by Britain and that the US won that war even though invading US troops were driven out of Ontario, the US capitol was burned to the ground, and the US had to sue for peace. They believe that the Mexican War was Mexico's fault and that the US seizure of what is now the southwestern US was legitimate (Abraham Lincoln and Ulysses S. Grant thought otherwise), that the US had the right to colonize the Philippines after promising independence during the Spanish-American War, that the US had the right to seize what is now Panama (was part of Columbia) to build the Panama Canal, had the right to overthrow several Central American governments on behalf of American business interests, and had the right to overthrow Iran's democratically elected secular government in 1953 in order to prevent Iran from asserting ownership of its own oil. See Bacevich (2008), Chomsky (2004, 2007b), Cooley (2000), Johnson (2004), Khalidi (2005), Kinzer (2003, 2007), and Prestowitz (2004). At the same time most Americans believe that the US is not an imperialist power and that the widespread

disapproval of American foreign policy, and sometimes violent hatred of the US, is because they "are jealous of our way of life" or they "hate our freedom". But as Etan Thomas (*The Huffington Post*, August 25 2008) comments, "[I]n reality, they disagree [with] and despise the impact the policies of the U.S. has not only on their lives but on the entire world."

The present theocratic tendencies in the US (Phillips 2006) are odd, considering that the early "Founding Fathers" were not particularly religious in any organized religion sense. Most were deists, believing there is a God who stands behind and explains everything, but not taking the bible literally and distrusting organized religion. They wanted separation of government and religion not so much to keep religion out of government as to protect religious freedom *from* government. John Adams, who was a signer of the Declaration of Independence and the second president (after George Washington) rejected conventional Christian doctrines such as the Trinity and the divinity of Jesus. He believed that religion could be a force for good in individual lives and in society at large, but he distrusted churches. It was during Adams' presidency that a Treaty of Peace and Friendship with Tripoli was negotiated and enacted, which has a preamble saying " ... America is not in any sense founded on the Christian religion... [and] has in itself no character of enmity against the laws, religion or tranquility of Musselmen [sic] ...." The US Senate passed the treaty unanimously and President Adams signed it on June 10 1797. The same generality is true of the other Founding Fathers, for example George Washington, Thomas Jefferson, Benjamin Franklin, James Madison, and later on Abraham Lincoln. They were religious in various degrees in their private lives, but affiliation with religious denominations was nominal if at all and belief in orthodox Christian theology (e.g. miracles, the divinity of Jesus, the Trinity) was lacking. All believed in strict separation of church and state. So how did the US become the religion-driven country it is today? As Albright (2006), who was Bill Clinton's Secretary of State, comments, "those on the religious right tend to see criticism of America's global role...as providing aid to the enemy and comfort to the forces of evil." She adds "There is a parallel...between religious fundamentalism and the unquestioning jingoism that views all of history through a narrowly American lens." Perhaps it is that religion in the US has become part of the market economy and what emotionally satisfies and attracts the most "customers" wins. Also the US is a society dedicated to consuming, and if religion is part of the market economy then everyone has to have some, just like having to own a car, a house, a TV, an iPhone, and whatever everyone else has. If a high percentage of your fellow citizens have religion, as the polls suggest is the case, then there is pressure on everyone to have some too. Another factor may be the loss of community in the highly mobile US. Belonging to a church provides that for many people—even if you move far away you can always find a congregation of your church.

I fear for the world (a possible attack on Iran for example?) but we will just have to see. Some authors are hopeful, for example Robin Wright (2008) who has reported on and written about the Middle East for three decades. She believes that "Islamic extremism is no longer the most important, interesting, or dynamic force in the Middle East" and that voices in the region—activists, reformers, political leaders and ordinary citizens—are pushing for a more open, democratic society. She points out that the two greatest obstacles to change are entrenched autocratic regimes and western especially US interests. Now the US is often distrusted more than the autocratic regimes which the citizens are opposing. Wright's focus is mostly on Palestinians, Arab countries, and Iran, not so much on Israel's role in the current impasse and its necessary role in any solution. The book has been widely acclaimed, for example by diverse American politicians (including the Vice President Elect Joesph Biden, former Secretary of State

Madeline Albright, and Richard Lugar the Republican leader of the Senate Foreign Relations Committee), an editor of the Israeli newspaper Haaretz, and a Lebanese newspaper columnist. How much this acclaim is wishful thinking remains to be seen.

This introduction has little to do with science *per se* but I wanted to begin by emphasizing that superficially religious politics, both domestic and international, both in Muslim countries and in the US, often have little to do with religion. They are in fact driven by other factors (money, power, nationalism) and religion is window-dressing. Prestowitz (2004), Carey (2001), Chomsky (2004, 2007a, 2007b), Cooley (2000), and Armstrong (2001b) make interesting background reading in this regard, and in support of what I have argued above. Burke (2006) describes how Islam has been used in this way, and Sen (2006) makes a convincing case for the effectiveness of tagging people with a single identity (e.g. religion: Islam, Hindu, fundamentalist Christian sects) to promote extremism and political loyalties. Both Saddam Hussein in Iraq and Hafez Asad in Syria, strongmen of very secular regimes, played the religious card when it was useful. So did all the American Presidential candidates, I notice. As for Islam, Mamdani (2004) comments that it is essentially apolitical, perhaps because it focuses on the individual relating to God rather than through an organization, also perhaps because it sees itself as within and part of (identified with) society and therefore not separate from or against it. Sunnis and Shia have somewhat different traditions in this regard, but the generalization is still valid. Of course individual Muslims are as political as anybody, but my point (and I think Mandami's) is that Islam is not itself political.

### **The Islamic civilization generally**

The Islamic civilization, at its height roughly 8th to 13th or 14th Century AD, was huge politically & culturally as well as religiously. It was sort of a "Pax Islamica" but more civilized and cultured than the British version. And cleaner—bathing several times a day partly as preparation for prayers—in contrast to the British whose sailors "overpowered" the Japanese with their body odour when their ships first visited. In fact, after the "Reconquest" of Spain, when the Inquisition was beginning, the dirtier less cultured Christians used bathing-too-much as an indication that some "Conversos" (Muslim => Christian) were not serious converts.

A good Muslim could travel within the Islamic civilization from the Atlantic Ocean (Spain or Morocco) to India and on to the Pacific Ocean (Southeast Asia), as ibn Battuta (ca. 1304-1370) did (Dunn 1986). So many travelled so much that rules were needed for being a good Muslim, especially at fringe places where many non-Muslims would be encountered. Al-Misri (1302-1367) wrote "*Reliance of the Traveller*" as a guide, a sort of early *Lonely Planet* guidebook for the Muslim traveller. Despite all the talk about the decline of the Islamic world, it is interesting to note that a Muslim traveller could do pretty much the same thing today.

One theory about the decline was that decreased openness to empirical science was a cause of it, related to the ca. 11th Century rise of the Ash'ari school. The "gates of Ijtihad" closed in the 10th Century (Ijtihad = the process of making a legal decision by independent interpretation of the legal sources, especially in new situations) and the subsequent effect was on philosophy and science as well as religion. (See discussion below about Al-Ghazali and other 10th-12th C. philosophers.) But more recently the thinking is that the Ash'ari school was not against empirical science, but rather against highly speculative philosophy (in our sense of the

word) without evidence. The decline probably had more to do with the mid 13th Century Mongol invasion (the trauma of which reinforced the religious conservatives and the shutting down of independent reasoning and thus innovation), and a commercial decline caused by loss of international trade, especially after the fall of Granada (the completion of the Christian Reconquest of Spain) in 1492. The Crusades (seven of them between 1096 and 1291) sapped the Islamic economy and the population, so that both prosperity and population were declining by the 14th and 15th Centuries in contrast to Europe where both were increasing. A good website discussing all the theories about the decline of the Islamic Civilization (which began in pre-Ottoman times) is at [www.history-science-technology.com/Articles/articles%208.htm](http://www.history-science-technology.com/Articles/articles%208.htm) . The theory that the decline was caused by a more conservative Islamic theology is rejected. See also Hobson's (2004) view of the role of the West in the Islamic Civilization's decline.

Two good general references for the origin and history of the Abrahamic religions (Judaism, Christianity, and Islam) over the millennia are Karen Armstrong's 1993 "*A History of God*", and F.E. Peters' 2003 "*The Monotheists*".

### **Science and religion in Islamic civilization and its interfaces with other cultures**

Before "science" became a word its forerunner was "philosophy". In discussing the medieval period, Fremantle (1954) notes that philosophy means "love of wisdom" (philo = love and sophia = wisdom), or in some dictionaries "the love of wisdom leading to the search for truth". Plato (427-347BC) said that the first characteristic of the philosopher is that he must be prepared to follow the answers wherever the argument goes. Aristotle (384-322BC) and St. Augustine (354-430AD) said similar things. Fremantle says the distinction between philosophy and science is only in what is dealt with, that science deals with some particular portion or aspect of reality arbitrarily abstracted from the whole by the human mind, whereas philosophy is concerned with the whole, for example whether the universe is caused or self-explanatory. By the early 13th Century Christian Europe was emerging from the medieval Dark Ages aided by contacts with the Islamic world which had preserved knowledge from the Greeks, Indians and Persians, and also developed it further and innovated themselves. Many translations into Latin from Arabic were being done, centered on Paris. Aristotle was rediscovered, for example. Both Averroes (ibn Rushd), 1126-1198AD, and Thomas Aquinas, ca. 1225-1274AD, called Aristotle "The Philosopher". Fremantle remarks that for medieval man he was also *the* natural scientist, a sort of super-Einstein-cum-Dewey. The Arabs had begun translating Aristotle in early Abbasid times, around the same date as the coronation of Charlemagne in the West (AD 800), and for the next 300 years there can be no question (this from a Catholic writer) that intellectually Cairo and Baghdad far outshone any contemporary European city. In fact they vied with each other as the greatest centers of learning in the world, with Cordova in Spain running a close third. By the 10th Century the Arabs had divided the sciences into the Arab sciences (e.g. grammar, ethics, history and literature), and the old or non-Arab sciences (e.g. philosophy, natural sciences and medicine).

Very early on, Islam encountered the knowledge of India, Persia and the Greeks. At that time religion and philosophy played major roles that were different from our usage of those terms today. The importance of beliefs in religion is pretty much a Christian invention (e.g. Frend 1982, Wilson 2008). Religion was, and still is in Judaism and Islam, mostly practice, ritual, observance, worshipping, living well—it is not arguing and persecuting about theological

beliefs. It is characterized by “orthopraxy” not by “orthodoxy”. The early Christians did not get into trouble with their pagan (i.e. non-Jewish non-Christian) Roman neighbors because of what they believed, but because they refused to sacrifice to the civic gods who protected the society at large (Fox 1985). What you believed about the nature of God, or exactly how the universe (or humans) came to be, or what is matter, etc., was the realm of philosophy not of religion. Thus, with the exception of Christianity and its emphasis on correct belief systems, religion was *a priori* something separate from and not in conflict with philosophy (out of which came science). A conflict between religion and science would not have been a concept easy to understand in the pre-Christian pagan (e.g. Greek) or Jewish cultures in Jesus’ day. Most of Jesus’ teachings that are thought to be genuine fit well into his Jewish culture (e.g. Maccoby 1987, Charlesworth 1996, Bloom 2007, Wilson 2008) and are about how Jews should live, not about what to believe. What to believe about Jesus came much later (Rubenstein 2000, Wilson 2008). That a conflict between religion and science even became possible conceptually was largely a Christian construct. So philosophy, part of which became science, could co-exist more easily with other religions than was possible with Christianity, both before and after the beginning of Christianity. Islam inherited the non-Christian attitude. In many ways Islam was a rejection, or a corrective, of the way orthodox Christianity developed in the 2nd through the 4th Centuries, including rejection of the belief system about a divine son of God who was also God, and by extension the emphasis on “right belief systems” in general. “Right practice” i.e. the right way to worship and to live were and are more important than “right belief” in Islam, in Judaism, and in pagan religions—both the pre-Christian pagan religions and the Arab pagan society into which Muhammed was born.

Many nonconforming Christians, for example Arian-leaning Christians, Nestorians, Donatists, and remnants of early Jewish Christians, willingly converted as the Islamic tide swept across the eastern Mediterranean and North Africa in the 7th Century (Bloom 2005, p. 29; Frend 1982, p. 204). What these “heretic” Christians believed about Jesus was probably closer to what the Muslims believed than it was to the 5th-7th Century orthodox Christianity of Rome, enforced by the Roman Empire. It was also probably closer to what the earliest Christians believed (Boulton 2008, Wilson 2008). Many of these non-orthodox Christians probably saw the Muslims as liberators, not as conquerors or as proponents of an antagonistic or rival religion. Some good general references about early Christianity and how it changed to become the orthodox Christianity of the Roman Emperor Constantine’s 4th Century AD, and thereafter, are: Bloom (2005), Boulton (2008), Ehrman (2005), Pelikan (1995, Charlesworth (1996), Crossan and Watts (1999), Dunzl (2007), Ehrman (1996, 2003, 2005), Fredriksen (2000), Frend (1982), Fox (1987), Grant (1971), Martin (2006), Neusner (2001), Norris (1980), Rubenstein (2000), and Wilson (2008).

In Islam empirical science had its foundation in Qur’anic precepts, e.g. 17:36 “You shall not accept any information, unless you verify it for yourself. I have given you the hearing, the eyesight, and you are responsible for using them.” This continued to be the attitude right through to the political decline of the Islamic empire. It can be argued that Islam itself was in fact a driver of scientific development in the Islamic civilization, not just a “permitter”, and certainly not an obstacle. A few examples are: the need for clean water for the washing involved in prayer rituals, the importance of astronomy and accurate calendars for calculations of important religious dates (e.g. the start and end of Ramadan) and for navigation for travelling including the Haj and for commerce; the need to know the geometry of the earth so that the

direction of Mecca could be determined from everywhere; and the need for an efficient and productive agriculture to maintain a healthy well-fed Ummah.

In the disciplines we now call “science” Islam took scientific ideas from India, from Sassanid Persia (226-652AD), from the Greeks, and even from China. Mathematics was developing in India from 400AD, and astronomy (but a geocentric version) from the 5th Century AD. An early calendar was developed. In physics there was an early concept of the atom and around the 5th Century BC theories about light. Pre-Islamic India also contributed to medicine and civil engineering (e.g. architecture). From pre-Islamic Persia came mathematical ideas, astronomy (e.g. some of the first astronomical tables), and medical advances. Advances in agriculture especially irrigation probably came to Persia from the Greeks in the mid-Sassanid period by way of the spread of Christianity, for example Nestorians. Early windmill-driven water pumps were developed and used in Persia. From the Greeks came developments in astronomy. The philosopher Thales predicted a solar eclipse in 585BC. In mathematics there were developments in geometry (Pythagoras) and algebra. Rational and irrational numbers were established as concepts. There were some ideas in cosmology and evolution but they were not much like modern concepts—the world was a circular flat disk with a rim and life arose from warm rain falling on earth. In medicine we all know of Hippocrates and we know of Plato and Aristotle for their speculations in cosmology and natural history. Muslims learned papermaking from two Chinese prisoners from the battle of Talas (present-day Kyrgyzstan) in 751AD between the Arab Abbasid Caliphate and the Chinese Tang dynasty for control of the river Syr Darya. The Arabs built paper mills in Samarkand and Baghdad, and they improved the Chinese process by using linen instead of tree (mulberry) bark. Hobson (2004) and Saliba (2007) are good references to Eastern origins of what we now call Western civilization, which were transmitted and augmented by the Islamic civilization.

Because most texts were written in Arabic the phrase “Arab science” is sometimes used but it is misleading. There were a number of notable non-Arab scientists within Islamic science, and even some non-Muslim scientists who worked productively in the tolerant Islamic civilization. A traditional “Orientalist” view is that Islamic science was admirable technically in many ways but that it did not innovate much and mainly served to preserve ancient knowledge and pass it to medieval Europe after the “Dark Ages”, making only minor advances in the process. However the recent dominant view is that Islamic science made a number of significant advances in experimental science. Some (e.g. Durant 1980, Iqbal 1999 first published in 1934) go further and argue that important foundations of experimental science were laid by introduction of an early scientific method and an empirical, experimental approach to scientific inquiry. Some now argue that Islam actually drove the “Islamic Scientific Revolution” and didn't just permit it to be driven by other factors. Especially in mathematics it is difficult to argue that very original advances were not made. The number of important and original Arabic works in mathematics greatly exceeded the total of Greek and Latin works (Swerdlow 1993).

I will now review some of the scientific advances within the Islamic civilization so you can judge for yourselves. Some general reading is Hassan and Hill (1986), Turner (1997), Hobson (2004), and Graham (2006).

In mathematics, we acknowledge our debt every time we use the word “algorithm” (from Al-Khwarizmi 780-850AD) and the word “algebra” which comes from the title of his book *Kitab al-Jabr*. “Arabic numerals” in fact came from India but Muslims innovated decimal point notation. Al-Kindi 801-873AD pioneered cryptology and cryptoanalysis. Al-Karaji (around

1000AD) proved the binomial theorem and Pascal's Triangle, using mathematical induction for the first time as far as is known. In the 11th Century Omar Khayyam (1048-1122AD), who is best known for his poetry (especially the *Rubaiyat*), was the first to find general geometric solutions of cubic equations, and he laid the foundations for analytical geometry and non-Euclidean geometry. One (unpublished) comment about Islamic mathematics is that "... many of the ideas which were previously thought to have been brilliant new [European] conceptions of the 16th, 17th and 18th centuries are now known to have been developed by Arab/Islamic mathematicians around four centuries earlier." A good introductory reference is Berggren (1986). An online "Bibliography of Mathematics in Medieval Islamic Civilization" is at <http://www.math.uu.nl/people/hogend/Islamath.html> .

Obviously astronomy needs mathematics and these two sciences reinforced each other. Good references are Gingerich (1986), Saliba (1994), and Huff (2003). In early sources the same Arabic word was used to refer to both astronomy and astrology, but by medieval times a clear distinction is made between "science of the stars" (astronomy) and "science of the celestial orbs"(astrology). Both are rooted in Greek, Persian and Indian traditions. Under the Islamic empire astrology was criticized by both scientists and religious scholars, much as it is today, but astrological predictions did require substantial knowledge and expertise and thus encouraged the study and development of astronomy. In the 11th Century al-Biruni made the distinction between astronomy and astrology, and refuted the latter. Other Muslim astronomers who refuted astrology were al-Farabi, Ibn al-Haytham, Ibn Sina (Avicenna), and Ibn Rushd (Averroes), on the grounds that the methods used were conjectural rather than empirical. Greek and Indian knowledge was refined by Muslim astronomers. Astronomical tables were developed by Al-Khwarzmi and al-Majriti and were used by Europeans rediscovering astronomy. In the 11th Century the Ptolemaic system began to be questioned and the shift to a heliocentric model began. The possibility of a heliocentric model with elliptical orbits was discussed by al-Balkhi, al-Haytham, al-Biruni, al-Sijzi, al-Qazwini, and al-Shirazi. Copernicus' early 1500s arguments for the earth's rotation were similar to those of al-Tusi and al-Qushji two centuries earlier. Other contributions were: the suggestion by Biruni that the Milky Way is a collection of many nebulous stars, optical writings by ibn al-Haytham laying the foundations for telescopic astronomy, and the first elaborate experiments in astronomy. See Saliba (1994). There are also several verses in the Qur'an which seem to foreshadow the "big bang" theory (21:30 - "Don't those who reject faith see that the heavens and the earth were a single entity then We ripped them apart?") and the expanding universe (51:47 - "And the heavens We did create with Our Hands, and We do cause it to expand"). Hadiths attributed to Muhammed (ca. 570-632AD) indicate that he was opposed to astrology and superstition in general. For example, when his son died there was an eclipse and rumours spread that it was God's condolence. Muhammed is said to have replied "An eclipse is a phenomenon of nature. It is foolish to attribute such things to the death or birth of a human being."

There were advances in chemistry, some related to perfumery. The experimental method was introduced to chemistry, as was the still, retort, pure distillation, crystallisation, purification, oxidation, evaporation and filtration. Much of this is associated with the name of 9th Century Jabir ibn Hayyan (called Geber in the West), who has been called the father of modern chemistry. Al-Kindi refuted alchemy and transmutation of metals (Klein-Frank 2001). Al-Tusi stated an early version of the conservation of mass. Durant (1980) remarks that "Chemistry as a science was almost created by the Moslems; for in this field, where the Greeks (so far as we know) were confined to industrial experience and vague hypothesis, the Saracens introduced precise observation, controlled experiment, and careful records."

Garrison (1913), among others, believed that modern geology began in the medieval Islamic world. Al-Biruni (973-1048) was one of the earliest Muslim geologists. He hypothesized that India was once a sea. He measured the earth by triangulation and estimated the radius to be 6340 km (it is 6378.1 km), an accuracy not obtained in the West until five centuries later. Ibn Sina (Avicenna, 981-1037) contributed to geology and related natural sciences. His encyclopedic work *Kitab al-Shifa* (the *Book of Healing*) contains his essay on Mineralogy and Meteorology, in six chapters. Principles he described became known in Renaissance Europe as laws of superposition of strata, of catastrophism, and of uniformitarianism. Toulmin and Goodfield (1965) commented "Around A.D. 1000, Avicenna was already suggesting a hypothesis about the origin of mountain ranges, which in the Christian world would still have been considered quite radical eight hundred years later".

The earliest environmental treatises were written, covering air and water pollution and soil contamination. Environmental impact assessments were done for certain localities.

Ibn Sina (Avicenna) is also famous as a pioneer of experimental medicine (see Campbell 2001 first published 1926). His early 11th century books remained standard textbooks until the 17th century in Muslim and European universities (e.g. Universities of Montpellier and Louvain). Al-Qasim (936-1013) invented a number of the surgical instruments we use today, and has been called the father of modern surgery (Martin-Araguz 2002). Moses Maimonides (1135-1204) was a Jewish rabbi, physician and philosopher in Muslim Spain (Andalusia), born in Cordoba near the end of the golden age of Jewish culture in Spain, following the first centuries of Moorish rule. The Almohades from Africa conquered Cordoba in 1148 and threatened Jews with choosing death, conversion or exile. After a decade of dodging about southern Spain his family, along with most other Jews, chose exile. He settled near Fez in Morocco and acquired most of his secular knowledge at the *University of Al-Karaouine*, founded in 859 and thought to be the oldest continuously operating institution of higher learning in the world (1998 *Guinness Book Of Records*). He was considered to be the greatest physician of his time. In later life he settled in the Holy Land and then Egypt and during the Crusades he treated both Saladin and Richard Lionheart. He is remembered for the philosophical insight that truths derived from human intellect cannot contradict revealed truth, so it follows that what we call science should not conflict with religion.

In physics, Ibn Sahl (940-1000) of Baghdad discovered the law of refraction. Ibn al-Haytham (965- ca.1039) pioneered in optics, the use of the scientific method, and developed a theory of light and sight (Steffens 2006). Of course the development of astronomy and optics went hand in hand. Attraction between masses (gravity), inertia, momentum, a finite speed of light, and binocular vision were described and developed.

Muslim biologists developed evolutionary theories which were widely taught in medieval Islamic schools (but not including natural selection as a mechanism). Draper (1878), a contemporary of Charles Darwin, thought the "Mohammedan theory of evolution" to be developed "much farther than we are disposed to do". Muslim scientists really shone in agriculture and irrigation. They greatly improved the irrigation systems used by the Persians, and the irrigated agricultural production of Muslim Spain was a wonder to the Europeans who saw it. Of course the water distribution system also provided water for other uses, e.g.

cleanliness. Crop rotation was pioneered and new crops were introduced and evaluated by experimentation. Use of fertilizers was also introduced and experimentally evaluated.

During a period of time stretching across the 10th through the 12th Centuries brilliant “polymaths” such as Al-Farabi and Ibn Sina struggled with the relationships between religion and intellectual knowledge (philosophy and what became science), influenced by Aristotle and Plato. They also influenced and disputed with each other, and greatly influenced European Renaissance science and philosophy. Al-Farabi (870-950) was followed by Ibn Sina (981-1037) who made him famous. Al-Ghazali (1058-1111) disputed and refuted them both. His “*The Incoherence of the Philosophers*” vehemently rejected Aristotle and Plato. Ibn Rushd (Averroes, 1126-1198) replied with his “*Incoherence of the Incoherence*” and tried to return to a more pure Aristotelianism, but largely failed. In the end Al-Ghazali set the tone. Ibn Rushd and Al-Ghazali influenced Maimonides (see above). Good references are Corbin et al (1993), Leaman and Nasr (2001), and the Cambridge Companion to Arabic Philosophy (2005). Rene Descartes's 17th Century work “*Discourse on the Method (rest of title:of Rightly Conducting the Reason, and Searching for Truth in the Sciences)*” was obviously influenced by Al-Ghazali and some (e.g. Najm 1966) believe that Descartes was dishonest in not referencing Ghazali's work

Cutting across all scientific disciplines, the use of experimentation was probably the greatest Muslim contribution to science in general because it valued empiricism much more than previous civilizations. The Greeks for example had valued rationality, not empirical observation. If science is based on experiments to test hypotheses then the Islamic civilization created science. Ibn al-Haytham's name stands out in first describing a fair approximation of the modern scientific method, and applying it to optics and psychology. He also describes an early version of Occam's Razor and applies it to developing a planetary model. Others applied such experimental scientific methods to chemistry, geology, surgery and social sciences. Briffault (1928) remarks that “The debt of our science to that of the Arabs does not consist in startling discoveries or revolutionary theories; science owes a great deal more to Arab culture, it owes its existence.”

## Summary

Muslims have not forgotten their glorious past role in the development of science. They are much more aware of it than are people in the West. Their resentment is not against science so much as it is against the ignorance and prejudice of others who do not acknowledge their contribution to today's scientific status. It is especially frustrating when their modern attempts to advance scientifically produce fear and obstruction in Western countries that would rather have them backward, weak, and economically dependent—importers of technology which can be supplied or not as Western countries wish. In other words, the colonial system continuing.

## Reference List

- Adamson, P., and R.C. Taylor. 2005. Cambridge Companion to Arabic Philosophy. Cambridge University Press.
- Ahmad ibn Naquib al-Misri 1994. Reliance of the traveller: a classic manual of islamic sacred law. Amana Publications, Beltsville, Maryland.
- Albright, M. 2006. The mighty and the almighty: reflections on America, God, and world affairs. Harper, New York.

- Ali, T. 2002. *The clash of fundamentalisms: crusades, jihads and modernity*. Verso, New York.
- Armstrong, Karen. 1993. *A history of God: the 4,000-year old quest of judaism, christianity and islam*. Ballantine, New York.
- Armstrong, Karen. 2001a. *The battle for God*. Ballantine, New York.
- Armstrong, Karen. 2001b. *Holy war: the crusades and their impact on today's world*. Anchor Books (Random House), New York.
- Ashcroft, Bill, and Pal Ahluwalia. 2001. *Edward Said*. Routledge, London.
- Bacevich, A. 2008. *The limits of power: the end of American exceptionalism*. Metropolitan Books. New York, Heidelberg
- Berggren, J.L. 1986. *Episodes in the Mathematics of Medieval Islam*. New York: Springer-Verlag, New York
- Bloom, Harold. 2005. *Where shall wisdom be found?* Riverhead (Penguin), New York..
- Bloom, Harold. 2007. *Jesus and Yahweh: the names divine*. Riverhead (Penguin), New York.
- Boulton, David. 2008. *Who on earth was Jesus? The modern quest for the Jesus of history*. O Books, Hampshire, UK
- Briffault, Robert. 1928. *The making of humanity*. Allen & Unwin, Sydney
- Burke, J. 2006. *On the road to Kandahar: travels through conflict in the islamic world*. Penguin, London.
- Campbell, Donald. 1926, 2001. *Arabian medicine and its influence on the Middle Ages*. Routledge, London..
- Carey, R.ed. 2001. *The new intifada*. Verso, New York
- Carter, Jimmy. 2007. *Palestine: peace not apartheid*. Simon and Schuster, New York.
- Charlesworth, J.H. 1996. *Jesus' jewishness: exploring the place of Jesus within early judaism*. Crossroad Publishing Company, New York.
- Chomsky, Noam. 2004. *Hegemony or survival: America's quest for global dominance*. Holt, New York.
- Chomsky, Noam. 2007a. *Failed states: The abuse of power and the assault on democracy*. Holt, New York.
- Chomsky, Noam. 2007b. *What we say goes: Conversations on U.S. power in a changing world*. Metropolitan Books, New York
- Cooley, John. 2000. *Unholy wars, Pluto*, London.
- Corbin, Henry, Hossein Nasr, and Utman Yahya. 1993. *History of Islamic philosophy*. Keegan Paul International, London.
- Crossan, J.D., and R.G. Watts. 1999. *Who is Jesus? Answers to your questions about the historical Jesus*. Westminster John Knox Press, Louisville KY
- Dershowitz, Alan. 2004. *The case for Israel*. Wiley, New York. (*also read Neumann 2005*)
- Draper, J.W. 1878. *History of the conflict between religion and science*. ISBN 1603030964
- Dunn, R.E. 1986. *The adventures of Ibn Battuta: a muslim traveler of the 14th century*. University of California Press, Berkeley Calif..
- Dunzl, F. 2007. *A brief doctrine of the trinity in the early church*. T&T Clark, London.
- Durant, Will. 1980. *The age of faith (Vol. 4 of The Story of Civilization)* Simon & Schuster, New York
- Ehrman, Bart D. 1996. *The orthodox corruption of scripture: The effect of early Christological controversies on the text of the New Testament*. Oxford.
- Ehrman, Bart D. 2003. *The new testament and other early Christian writings: a reader*. Oxford.
- Ehrman, Bart D. 2005. *Lost Christianities: The battles for scripture and the faiths we never knew*. Oxford.
- Esposito, J.L., and D. Megahed. 2008. *Who speaks for Islam? What a billion muslims really think*. Gallup Press, Washington D.C.
- Fox, R.L. 1987. *Pagans and Christians*. Knopf, New York.
- Fredriksen, P. 2000. *From Jesus to Christ*. Yale University Press, New Haven
- Fremantle, A. 1954. *The age of belief: the medieval pholosophers*. New American Library (a Mentor Book), New York.
- Frend, W.H.C. 1982. *The early church*. Fortress, Minneapolis MN.
- Garrison, F. H. 1913. *An Introduction to the History of Medicine*. Saunders, Philadelphia.
- Gingerich, Owen. 1986. *Islamic astronomy*. *Scientific American* **254**(10): 74.
- Graham, Mark 2006. *How Islam created the modern world*. Amana Publications, Beltsville, Maryland..
- Grant, R.M., and M.M. Mitchell. 1971. *Augustus to Constantine: the rise and triumph of early Christianity in the Roman Empire*. Collins, New York.
- Hassan, A.Y., and D.R. Hill. 1986. *Islamic technology: an illustrated history*. Cambridge.
- Hobson, J.M. 2004. *The eastern origins of Western Civilization*. Cambridge.
- Huff, Toby. 2003. *The Rise of Early Modern Science: Islam, China, and the West*. Cambridge University Press, Cambridge
- Huntington, S.P. 1996. *The clash of civilizations and the remaking of world order*. Simon & Schuster, New York.
- Iqbal, Muhammed. 1934, 1999. *The reconstruction of religious thought in Islam*. Kazi Publications, Chicago

- Johnson, Chalmers. 2004. *Blowback: the costs and consequences of American empire*. 2<sup>nd</sup> Ed. Holt, New York.
- Khalidi, R. 1997. *Palestinian identity: the construction of modern national consciousness*. Columbia University Press, New York.
- Khalidi, R. 2005. *Resurrecting empire*. Beacon Press, Boston..
- Khalidi, R. 2006. *The iron cage: the story of the Palestinian struggle for statehood*. Beacon Press, Boston.
- Khalidi, R. 2008. *Palestine: Liberation Deferred*. In: *The Nation*, May 26 2008.
- Kimmerling, Baruch. 2003a. *The Palestinian people: a history*. Harvard Univ. Press, Cambridge MA
- Kimmerling, Baruch. 2003b. *Politicide: Ariel Sharon's war against the Palestinians*. Verso, New York.
- Kinzer, S. 2003. *All the Shah's men: an American coup and the roots of middle east terror*. Wiley, New York.
- Kinzer, S. 2007. *Overthrow: America's century of regime change from Hawaii to Iraq*. Times Books, London.
- Klein-Frank, Felix. 2001. "Al-Kindi", In O. Leaman & H. Nasr, *History of Islamic Philosophy*, p. 174. Routledge, London.
- Lane-Poole, S. 2001. *The Muslims in Spain*. Goodword Press, New Delhi.
- Leaman, O., and H. Nasr. 2001. *History of Islamic philosophy*. Routledge, London.
- Lewis, B. 2002. *What went wrong?: the clash between islam and modernity in the middle east*. Perennial (HarperCollins) New York..
- Lowney, C. 2005. *A vanished world: medieval Spain's golden age of enlightenment*. Free Press (Simon & Schuster), New York.
- Maccoby, Hyman. 1987. *The mythmaker: Paul and the invention of Christianity*. HarperCollins, New York.
- Mahmood Mamdani 2004. *Good muslim, bad muslim: America, the cold war, and the roots of terror*. Pantheon, New York.
- Martin, S. 2006. *The gnostics: the first christian heretics*. Pocket Essentials, Harpenden, Herts.
- Martin-Araguz, A., C. Bustamante-Martinez, Ajo V. Fernandez-Armayor, and J. M. Moreno-Martinez. 2002. Neuroscience in al-Andalus and its influence on medieval scholastic medicine. *Revista de neurología* **34** (9): 877-892.
- Mearsheimer, J.J., and S. M. Walt. 2008. *The Israel Lobby and U.S. Foreign Policy*. Farrar, Straus and Giroux, New York.
- Meddeb, A. 2003. *The malady of Islam*. Basic Books (Perseus), New York.
- Najm, S. M. 1966. The Place and Function of Doubt in the Philosophies of Descartes and Al-Ghazali. *Philosophy East and West* **16**: 133-41
- Neumann, M. 2005. *The case against Israel*. CounterPunch, Petrolia, Calif. (refer to Dershowitz 2004)
- Neusner, J. 2001. *Jews and Christians: the myth of a common tradition*. Global Publications, Binghamton University.
- Norris, R.A., Jr. 1980. *The christological controversy*. Fortress Press, Minneapolis MN.
- Oz, Amos. 1994. *Israel, Palestine and peace (essays)*. Harcourt Brace, Orlando, FL
- Oz, Amos. 2006. *How to cure a fanatic*. Princeton Univ. Press, Princeton NJ.
- Pelikan, Jaroslav. 1995. *Christianity and Classical Culture: The Metamorphosis of Natural Theology in the Christian Encounter with Hellenism*. Yale University Press, New Haven CT.
- Peters, F.E. 2003. *The monotheists: jews, christians, and muslims in conflict and competition*. Princeton University Press, Princeton.
- Phillips, Kevin. 2006. *American theocracy: the peril and politics of radical religion, oil, and borrowed money in the 21<sup>st</sup> Century*. Penguin, New York.
- Prestowitz, Clyde. 2004. *Rogue nation*. Basic Books (Perseus), New York.
- Quigley, John. 2005. *The case for Palestine: an international law perspective*. Duke Univ. Press, North Carolina.
- Ramadan, Tariq. 2003. *Western muslims and the future of Islam*. Oxford.
- Rubenstein, R.E. 2000. *When Jesus became God: The struggle to define Christianity during the last days of Rome*. Harvest.
- Said, Edward. 1978, 2003. *Orientalism*. Penguin, London.
- Said, Edward. 1995. *The politics of dispossession: Struggle for Palestinian self-determination, 1969-94*. Vintage (Random House), New York
- Said, Edward. 1997. *Covering Islam: how the media and the experts determine how we see the rest of the world*. Vintage (Random House), New York.
- Said, Edward. 2002. *Power, politics, and culture*. Vintage (Random House), New York..
- Saliba, George. 1994. *A history of arabic astronomy: planetary theories during the golden age of Islam*. New York University Press, New York.
- Saliba, George. 2007. *Islamic Science and the Making of the European Renaissance*. MIT Press, Cambridge MA.
- Sen, A. 2006. *Identity and violence: the illusion of destiny*. Norton, New York.
- Steffens, Bradley. 2006. *ibn al-Haytham: First scientist*. Morgan Reynolds Publishing, Anaheim CA.

- Swerdlow, N.M. 1993. Montucla's legacy: the history of the exact sciences. *Journal of the History of Ideas* 54: 299-328.
- Toulmin, Stephen, and June Goodfield. 1965. *The Ancestry of Science: The Discovery of Time*. University of Chicago Press, Chicago.
- Turner, H.R. 1997. *Science in medieval Islam: an illustrated introduction*. Univ. of Texas Press.
- Wilson, Barrie. 2008. *How Jesus became Christian*. St. Martin's Press (Macmillan), New York.
- Winder, Bayly. 1981. Review of Edward Said's *ORIENTALISM*. *Middle East Journal* 35: 615-618.
- Wright, Robin. 2008. *Dreams and shadows: the future of the Middle East*. Penguin, New York.

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