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Regenerating Muslim Inventors – The Present Future

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Abstract

Much discussion has been done about the golden era of Muslim civilization and its decline over the past centuries. Recent downturn of events in the Middle East has given birth to the Muslim refugee crisis, coupled with terrorist attacks have fueled the growth. Now more than ever, Muslim need inspirational role models, to survive this crisis and backlash. This paper intends to highlight the achievements of Muslim scientists, engineers and innovators, dating from the early 9th century to the more recent 21st century. Some of the works discussed in this paper are not so commonly discussed, such as the work of Banu Musa on control theory and mechanical pumps by Al-Jazari. Next special highlight is done on the works of Muslim Nobel Prize winners as well as their attempts to encourage other Muslims to be involved in science and technology. Finally, we discuss the successful Muslim inventors of the 21st century, both who created modern devices for communications and lasers. The paper concludes with a critical discussion on what are the qualities that these Muslim technologists had to succeed and how the modern generation can emulate them.

Keywords: *Muslim civilization; middle east; Muslim scientist; 9th century; Nobel prize*

1. Introduction

The decline of the Muslim civilization has been a well-discussed topic amongst Muslims, be it in literature, conferences or even in day-to-day conversations. The malaise affecting the Muslim world is so apparent, the most obvious being in the field of technology as well as in terms of governance of their countries, making Muslim world countries among the poorest and most corrupted among nations. This has gotten worse in recent years with the rise of terrorism associated with Muslims, giving birth to Islamophobia.

Now more than ever, Muslims need positive role models in order to survive and try to rise amongst all the hatred surrounding them. Sources of inspiration have often been derived by studying the Muslim scientists who lived during the golden Age of Muslim Civilization between the 8th to 15th centuries. During this period, Muslim scientists and inventors were very prolific, leading the way in the areas of astronomy, physics, philosophy and medicine. To rejuvenate and remind us of the success of the past, so that it can inspire us to do better, we have described the works of selected Muslim mechanical engineers who lived in this period. We start with the works of Banu Musa brothers, who are well known for their contributions in the field of mechanical and control systems. Between the three of them, they developed a plethora of devices such as valves, feedback controller, automatic flute player, a programmable machine, and self-trimming lamp. The next engineer is Al-Jazari, the father of robotics, who in his lifetime developed a variety of pumps, clocks and other machinery. After that we describe Taqi Ad-Din who lived in the 16th century, a famous astronomer and engineer, well known for his work on steam turbines. After the narrative of three ancient inventors, we now fast forward into the lives of successful Muslim scientists of the 21st century. We start with the work of the recent Nobel Prize winners in Physics and Chemistry respectively, Abdus Salam and Aziz Sancar. Next we describe the achievements of two modern Muslim inventors Hatim Zaghloul and Aziz Javan who are well known for their contributions in communications and lasers respectively. The final section will conclude the article and provide insight on how Muslims of the modern world might lead their lives to be respectable members of the community.

"If learning the truth is the scientist's goal, then he must make himself the enemy of all that he reads" – Ibn Al-Haytham

2. The golden age of Muslim civilization

The Islamic renaissance that began in the 9th century through to the 16th century sees the rise in advancement of science and technology within Islamic civilization. The Abbasid period through to Ottoman Empire flourished with vast significant contributions from Muslim scholars of Turkish, Persian and Arab origins in the field of natural sciences and technology. The Abbasid caliphate especially Al-Ma'mum emphasized and encouraged the systematic development of science and technology. A famous quote from Sir Isaac Newton, "If I have seen further it is by standing on the shoulders of Giants" mirrors the major achievements in science and technology of Islamic era that were derived from learning and improving achievements of the previous scholars. Al-Ma'mum made tremendous efforts to merge Islamic science and technology with the intellectual tradition of Greek, Sanskrit and Chinese knowledge. Many inventions created during this time are actually the foundations of many great technologies of current modern world. The Western history of techonology rarely acknowledges the contributions of the Muslim inventions and thus the purpose of this article is to highlight prominent Muslim engineers whose inventions have changed the world.

Banū Mūsā brothers (9th century)

The first effort in the Muslim world to establish intellectual discipline was started by Harun al-Rashid, the fifth Caliph of the Abbasid dynasty. The Caliph influenced Musa ibn Shakir to explore science and Musa later became highly proficient in astronomy. This penchant for scientific thinking and intellect was also inherited by his three sons who later famously known as the Banu Musa Brothers. The brothers are Jafar Muhammad who worked on geometry and astronomy, Ahmad who were proficient in mechanics, and al-Hasan who were the expert on geometry. Scientific discovery and knowledge flourished further in time through the establishment of an academy known as the House of Wisdom by Caliph al-Ma'mum, the son of Harun al-Rashid. In this house, the Banu Musa Brothers lay the foundation of the Arabic school of mathematics based on Greek mathematical work and introduced some important mathematical concepts for example the description of π as "*… the magnitude which, when multiplied by the diameter of a circle, yields the circumference*". [1]

Among the reputable engineering works by the Brothers are the construction of canals for a new city of al-Dja'fariyya during the reign of al-Mutawakkil (847-861). Their contributions in the field of mechanical sciences was recorded in their book titled "*The Book of Ingenious Devices"* [2]. The book described a total of 100 machines and detailed instructions on their mechanism and on how to use them. It is a compilation of the original works of the brothers as well as work from ancient texts including work of Heron of Alexandria and Philon of Byzantium. *The Book of Ingenious Devices* was then translated into Latin by Gherard of Cremona entitled *Liber trium fratum de geometria* and become famous in the western world.

Some of the inventions described in the book are: valve, float valve, feedback controller, automatic flute player, a programmable machine, trick devices, and self-trimming lamp. Atilla Bir, a professor at Istanbul Technical University analyzed these systems from the point of view of modern systems and control engineering and derived the corresponding block diagrams of the systems used in the inventions [3]. An example of Bir's work is shown in Fig. 1 where he derived the block diagrams for an automated oil level controller of an oil lamp invented by the brothers.

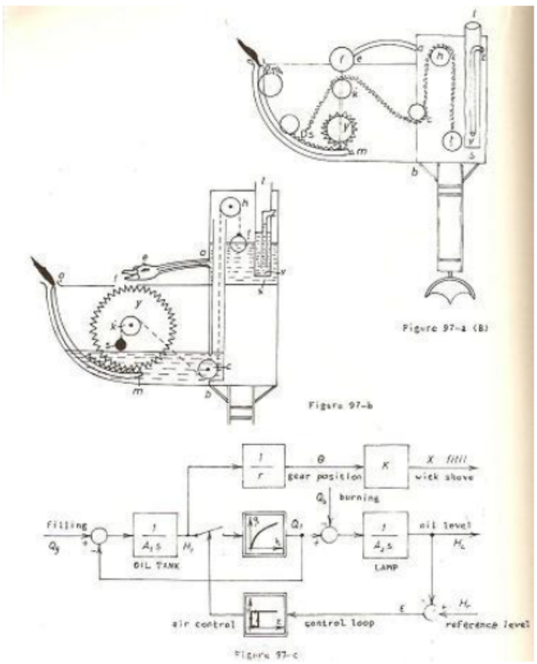


Fig. 1: The original drawing of an automatically controlled oil level oil lamp and the construction of the block diagrams based on modern control engineering [4]

Through their invention of water turbine and worm gears, the Banu Musa Brothers created models of sophisticated water fountains. The models consist of seven parts where the first model describes three basic styles of fountains; lily, shield and spear as shown in Fig. 2 [5]. The basic models are achieved by use of a balance, a wind/water turbine and a worm gear. The remaining six models describe how the three basic models can be integrated to form more intricate fountains, for example a fountain that can periodically change its water shape from one form to another.

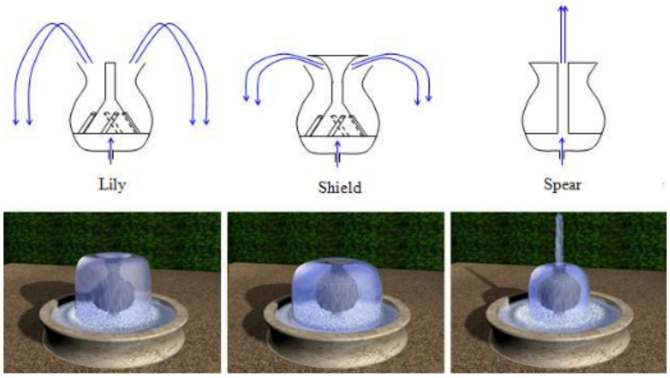


Fig. 2: The three basic styles of a fountain [5].

Other than the water fountains, the Brothers also documented their inventions on 73 trick vessels, 15 automatic control systems, 3 oil lamps, one bellow and one lifting mechanism system. The Brothers demonstrated excellent skills in prototyping navel valves and worm gears that showcased their skills with machinery and competency as a designer. Although it is not made clear on the applications of their inventions, the modern translation and analysis of Banu Musa inventions by Professor Bir gave special mention to the extraordinary ingenuity and inventiveness of the three brothers. The Banu Musa's mastery of delicate controls during the medieval time was unsurpassed until fairly recent times.

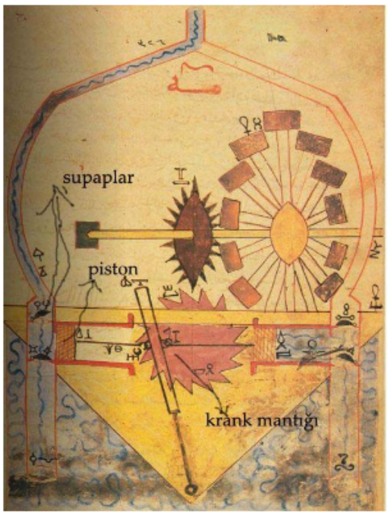
Ismail Al-Jazari (13^th^ century)

The work of Banu Musa inspired the 13th century renowned Muslim engineer named Al-Jazari. He was one of the most important inventors and engineers in the history of technology. Apart from works of Banu Musa, Al-Jazari also referred to works from Greek tradition for example Ctesibios (3rd century BCE), Philon (2nd century BCE) and Heron (1st century CE), and Arabic scientific tradition like al-Khazini (12th century)) [6]. Al-Jazari wrote his name as Al-Shaykh Ra'is al-A`mal Badi' al-Zaman Abu al-‘Izz ibn Ismail ibn al-Razzaz al-Jazari at the front page of his book titled *‘Al-Jami’ bayn al’Ilm al-Nafi’ wa sina’at al-hiyal*’. Ra'is al-A`mal indicates his title as a chief engineer, Badi' al-Zaman means unique and unrivalled and al-Shaykh refers him as a learned and dignified person [7]. The name Al-Jazari refers to the place of his birth, Al-Jazeera, a place between Tigris and the Euphrates in Mesopotamia.

Al-Jazari is known as the founder of cybernetic science and the first scientist to design robots [8]. He is acclaimed as the "father of robotics" due to his work on an early programmable humanoid robot and also as the "father of modern engineering" with his fundamental work on mechanical inventions [6]. Al-Jazari introduced machinery mechanisms and components like camshaft and crankshaft that transform rotary motion into linear reciprocating motion. This basic mechanism is the main feature of both the steam engine and the internal combustion engine that drives the modern world.

An English engineer and historian of science and technology, Donald R. Hill translated the most important work of Al-Jazari from Arabic to English in his published book "*The Book of knowledge of Ingenious Mechanical Devices*" [9]. He mentioned that until modern times, there is no other document on design, mechanism, manufacturing and assembly of machines that can match the importance and value of Al-Jazari works [10]. Scholars in Turkey have done an extensive study on Al-Jazari's works where Durmus Caliskan use modern engineering knowledge to explain the devices in great detail.

Among the amazing mechanical devices created by Al-Jazari are clocks, hand washer and wudhu' apparatuses, measuring instruments used in blood collection, various robots, water supply tools that helped to boost agricultural production at that time, fountains and devices and metal casting techniques. Fig. 3 shows a double suction pump invented by Al-Jazari for water pumping machines. This double suction pump is the origin of modern suction pump that utilizes a crank mechanism to convert rotary motion into reciprocating motion through a crank-connecting-rod. This pump is hand operated. When placed directly in water, the pump can extract ground water via vertical cylinders that have plate valves at the bottom. This pump of Al-lazari was introduced 200 hundred years before the introduction of suction pump by Taccola (1450) and it shows that during Muslim Civilization, engineers were familiar with piston pumps for a long time throughout the Middle Ages.



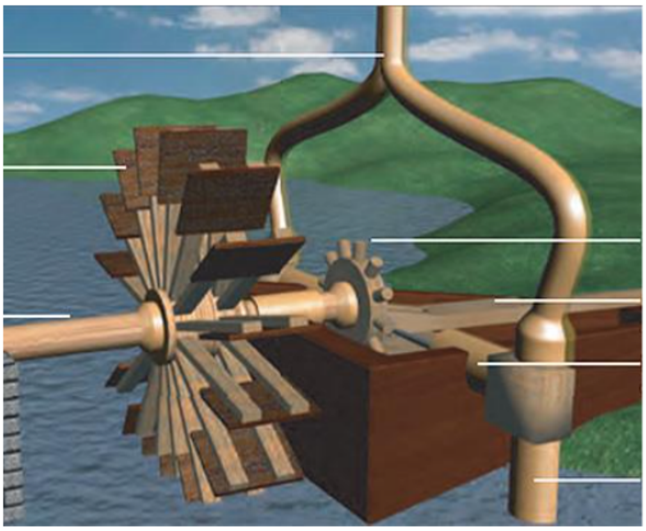


Fig. 3: (Left) A manuscript shows Al-Jazari's reciprocating pump. This was the first time an illustration of a crank appeared in a manuscript - (Right) 3D animated image of reciprocating pump [11]

Another water-pumping device invented by Al-Jazari that was used as a pool decoration is shown in Fig. 4. The figure on the left, shows a drawing of a cow that appears to run the mechanism, but the device actually works with a hidden paddle wheel hiding under water level [11]. The water-raising machines are driven by a water turbine through geared shafts, which turn a paddle wheel carrying a long belt of buckets that elevates water to 2.5 m high. The mechanism uses multiple gears with partial teeth that produces a sequence of motion in four scoops that gets filled with water, one scoop at a time, controlled by a camshaft. This structure itself is quite small, having two sections as shown in the right of Fig.4.

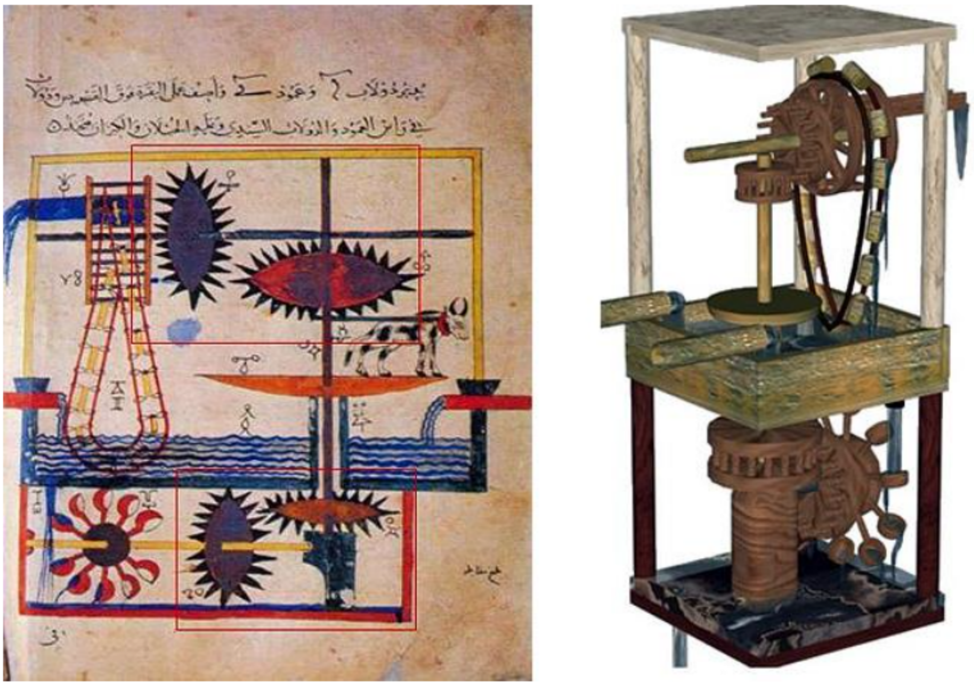


Fig. 4: Left: A water-raising machine designed by Al-Jazari from his manuscripts. Right: 3D Image of the device [12]

The most significant invention of Al-Jazari is the water powered elephant clock shown in Fig. 5. This invention is a harmonious integration of knowledge contribution from civilization of Greek, Egyptian, Indian, Chinese and Muslim. The timing mechanism of the clock is based on a water-filled bucket with a deep bowl floating in the water, but with a small hole in the center. The bucket will be filled with water through the small hole and it takes half an hour to get filled. With the reduced buoyancy, the bowl starts to sink and during the motion it pulls a string attached to a see-saw mechanism in the tower on top of the elephant. This causes a ball to drop into the mouth of a serpent and hence tips it forward while simultaneously pulling a string system that raises the hand of the figure in the tower. This motion causes the elephant driver at the front to hit a drum, indicating a half or full hour. The sunken water bucket then is raised out of water by a snake, and then the cycle repeats itself [13]. This was the first clock in which an automaton reacts after certain intervals of time and is the first example of a closed-loop system in a device.

Fig. 5: The Elephant Clock: Leaf from a manuscript of Al-Jazari's book, *The Book of Knowledge of Ingenious Mechanical Devices*) [14]

The mechanism of all of Al-Jazari's invention was described in a do-it-yourself style with text, illustrations and dimensions are described in detail such that the system or devices can be replicated by any skilled craftsmen. A huge replica of the elephant clock was reconstructed and now stands 8 meters high in the "India" court at the Ibn Battuta shopping mall in Dubai. Other Al-Jazari's components and techniques that are important to modern mechanical engineering includes the static balancing of large pulley wheels; calibration of orifices; use of wooden templates; use of paper models in design; lamination of timber to prevent warping; the grinding of the seats and plugs of valves together with emery powder to obtain a watertight fit; casting of brass and copper in closed mold boxes with greensand; use of tipping buckets that discharge their contents automatically; and the use of segmental gears [15].

Taqi ad-Din (16th century)

Taqi ad-Din was born in 1526 as Muhammad Ibn Ma'ruf in Damascus. He studied at a madrasah and establish himself as a religious scholar as well as a scholar in mathematical sciences. In 1550 he moved to Egypt with his father and became associated with a number of prominent scholars at the time. His close association with the Grand Vizier Samiz 'Ali Pasha allowed him private access to his private library and clock collection. Later he was appointed to become a qadi in Egypt. During his tenure, he studied mathematics and astronomy and gained access to the collections of works by Jamshid al-Kasha, and by Qaḍizade, among the most accomplished and prolific scientists at the Samarqand Observatory in the 15th century. During his studies, he made astronomical observations using an astronomical instrument that he mounted in a well that was 25-m deep [16].

By 1570, Taqi ad-Din had established his name as an engineer and scientist and became known in the Ottoman Empire. When he went to Istanbul, Sultan Selim II appointed him as the head astronomer in Istanbul and quickly became the most important astronomer of Ottoman Turkey [17]. He was the founder and the director of the Istanbul Observatory that was purposely built to correct astronomical charts prepared by Ulugh Beg, the famous Turkmen astronomer in the 15th century [18]. He was the first astronomer to use an automatic-mechanical clock for his astronomical observations [16]. His work in astronomy to correct the work of Ulugh Beg was recorded in *Sidrat muntahā al-afkār fī malakūt al-falak al-dawwār*. As a result of his observations, he found the eccentricity of the sun where his calculated value is more precise and accurate than the observation by Tycho Brahe, a Danish astronomer at the time, or Nicolas Copernicus, the renaissance era astronomer. However, the demolishment of the observatory put a stop on his astronomical observation and his book was never completed.

Apart from his contribution in astronomy, his contributions in mechanics are equally significant and his work in mechanical sciences started before his fame as an astronomer. In his book*, al-Kawākib al-durriyya fī waḍʿ al-bankāmāt al-dawriyya*, he described his pioneering work on mechanical-automatic clock in the Islamic and Ottoman world. In his second book on mechanics described his continuation study on geometrical-mechanical structure of clocks inherited from the work of Banu Musa and al-Jazari.

In 1551, Taqi ad-Din described in his book *Al-Turuq al-saniyya fi al-alat al-ruhaniyya*, a steam turbine as a way to power a rotating spit. The steam turbine uses steam to drive a wheel with vanes similar to windmill's sails, attached to a rotating spit [19]. This use of steam turbine as a power source preceded the work of Giovanni Branca in 1629 and John Wilkins in 1648. His steam turbine work was inspired from the work of Hero of Alexandria that uses the power of steam escaped from nozzles to rotate a device. The basic principle of steam engine written in his book paved way to the discovery of more powerful steam engine in the 17th century in Europe.

The same book also contains description of other important innovations of Taqi al-Din such as the six-cylinder water pump and water clocks. Fig. 6 shows the hydro powered six-cylinder engine that was invented in 1559 that uses crankshaft-connecting rod mechanism, inherited from the work of al-Jazari. A water wheel drives a camshaft to operate a six-cylinder monobloc pistons, equipped with non-return valves to create a vacuum, to pumped water into delivery pipes [19]. This work of Taqi ad-Din in mechanical sciences, as quoted from Islamic historian Ragheb el-Sergany, completes the Islamic Era's most crucial phase in mechanical engineering [20].

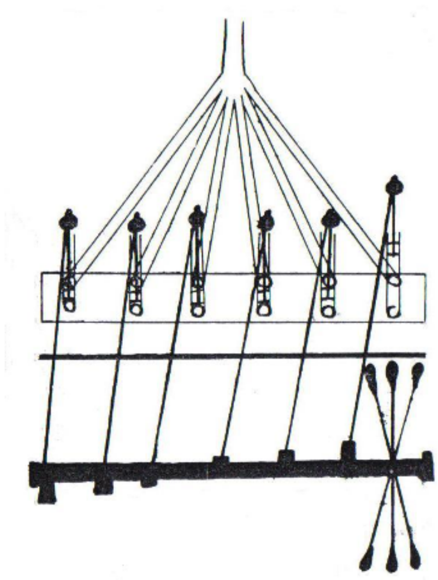


Figure 6: Drawing of the six-cylinder pump as it was depicted by Taqi al-Din in "The Sublime Methods of Spiritual Machines" (Chester Beatty Library in Dublin, Arabic MS 5232, p. 38) [19].

Until here, we have highlighted the three most famous mechanical engineers from the golden age of Islamic civilization. Their achievements are the results of the great effort by Islamic rulers of the time to institutionalise knowledge and scientific development alongside religious learning. The downfall of Islamic civilisation marked the decline of Muslim scholars. What's left behind are vast wealth of new ideas that enriched civilisation, embraced by western civilisation and ultimately contributed greatly to European renaissance.

To give hope to the current generation of Muslims that all our successes are not all in the past, the next section of this article seeks to describe the achievements of modern Muslim scientists and inventors. Indeed, the Muslims society is currently besieged so many challenges such as war, persecution, displaced generations, Islamophobia and others. But Allah swt has always reminded us in the Quran (3:139) to never give up and continue to bring glory to our religion.

"and don't become weak, nor be sad, you will be superior if you are indeed true believers". (surah Ali-Imran, verse 139)

For the Muslim scholars, their jihad is the continuous pursuit of knowledge and indeed, Islamic teachings that urges all Muslims to continuously pursue knowledge throughout their lifetimes. Muslim societies have started to emerge from colonialism and neo-colonialism and are reviving the great contributions of Muslim scholars in this modern era of new knowledge. The following paragraphs attempts to celebrate each recent Muslim scholar so that the future generations will be encouraged to continue in this path. Each paragraph in the following section begins with a summary of the scientific achievement of the inventor, followed by a short biography of the scientist. It is interesting to note that in most cases, the scientists have not been solely focused on science, but have also found time to support the cause of Islam, be it for Muslims living in developing countries or Muslim immigrants that live in Western countries.

3. Muslim Nobel Prize Winners

Abdus Salam

Among the most famous Muslim scientists is Abdus Salam, a Pakistani theoretical physicist who won the 1979 Nobel Prize in Physics together with Steven Weinberg and Sheldon Glashow for their work in electroweak unification theory interactions. This theory describes two forces electromagnetism and weak interactions that commonly occur every day at low energies, can be combined at a specific unification energy. Their works were of extreme importance to the development in the field of particle physics.

The standard model of elementary particles shown in Fig. 7 describes the different types of elementary particles (quarks and leptons) and the basic forces that are transmitted between them known as gauge bosons or vector bosons. Each different type of particle carries a different force. Photons carry the electromagnetic force, gluons carry the strong force; charged particles (W+ or -), neutral particles (Z0) carry the weak force and finally the gravitron is believed to carry gravity.

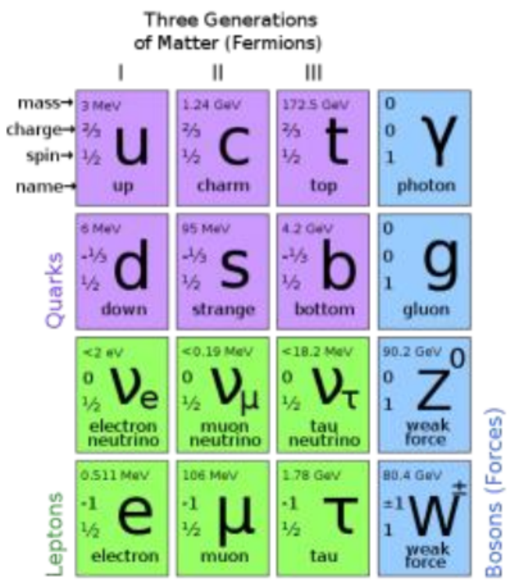


Figure 7. Standard Model of Elementary Particles [21]

Salam, Weinberg and Glashow found that when the electromagnetic and weak interactions of elementary particles combine above the unification energy ~246 GeV, they result into a single electroweak force. The weak force acts only across distances smaller than the atomic nucleus, as opposed to electromagnetic forces which can extend for great distances (as observed in the light of stars reaching across entire galaxies). This weak force is responsible for radioactive beta-decay, where the decay of the neutron with charge zero is transformed into proton which has a positive charge via the emission of an electron and a neutral, massless particle the neutrino. This weak force is also present in the chain of nuclear reactions that occur in the interior of the sun to create solar energy. For example, hydrogen is transformed into heavy hydrogen or deuterium in the first reaction due to the presence of this weak force. This strength of this weak force is ideal to sustain the lifespan of the sun and its planetary system. Having a larger force would shorten its lifetime.

The three scientists Salam, Weinberg and Glashow also verified the existence of a new type of weak interactions via two important experiments [22]. The first experiment conducted in 1973, discovered weak neutral currents during neutrino scattering using Gargamelle, the giant bubble chamber detector at CERN. The second set of experiments were conducted in 1983 using CERN's Underground Area 1 and 2 (UA1 and UA2) Super Proton Synchrotron (SPS) accelerator-collider. This experiment discovered the W and Z bosons or the elementary particles that mediate the weak interactions. UA2, a more specific detector compared to UA1 also measured the masses of the W and Z bosons and was able to detect particle jet-sprays of hadrons and other particles that form when a quark, gluon or antiquark is ejected during collisions [23]. The importance of this electroweak theory in comparison to all other forces in nature is shown in Fig. 8.

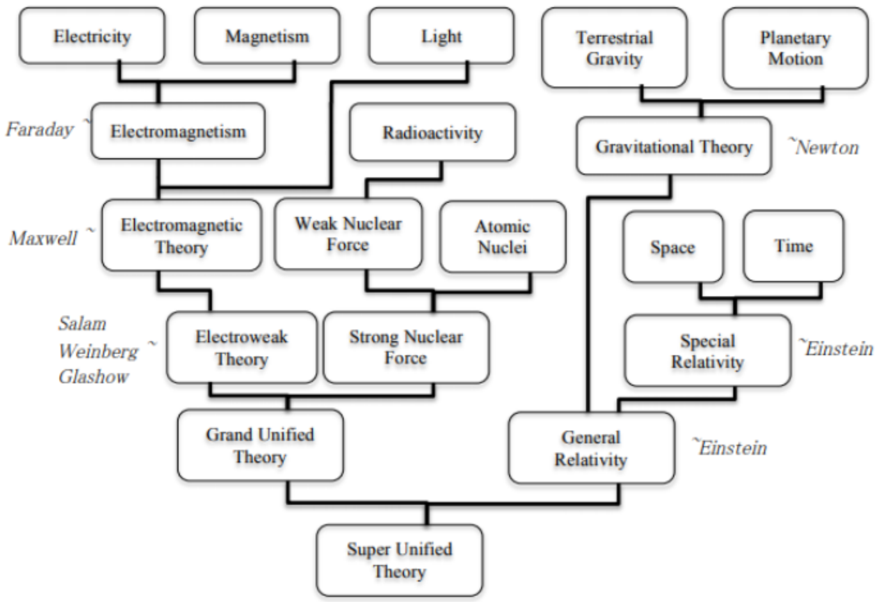


Fig. 8. Unification of the forces in Nature. [24]

Abdus Salam was born in Lahore, Pakistan in 1926. He was educated first in the University of Punjab where he earned his Masters of Arts in Mathematics in 1946. In this same year he was awarded a scholarship to St. John's College, Cambridge where he completed his Bachelor of Arts degree with double first-class honours in Mathematics and physics in 1949. He received the Smith's Prize in 1950 from Cambridge for the most outstanding pre-doctoral contribution to Physics [25]. His PhD in theoretical physics on fundamental work in quantum electrodynamics was published in 1951 and won him the prestigious Adam's Prize. Abdus Salam had intended to start a school of research in Pakistan upon completion of his PhD, but things did not work out as planned [25]. He returned to Cambridge in 1954 and later went on to be a Professor of Theoretical Physics at Imperial College as well as the Director of the International Center of Theoretical Physics (ICTP) in Trieste, Italy. Via ICTP, Trieste he started the famous "Associateships" which allowed deserving young and gifted theoretical physicists from developing countries spend their vacations to conduct research and interact with scientists at Trieste. Other than being a very prolific researcher in the field of theoretical elementary particle physics for more than 40 years, Salam has also served on a number of United Nations committees working to advance science and technology in developing countries. He has spent most of his Nobel Prize and Atoms for Peace Medal and Award winnings for the benefit of physicists from developing countries. Abdus Salam is a devout Muslim and he incorporated Islamic values both in his work as well as family life [22].

"*The Holy Quran enjoins us to reflect on the verities of Allah's created laws of nature; however, that our generation has been privileged to glimpse a part of His design is a bounty and a grace for which I render thanks with a humble heart*" – Abdus Salam.

Aziz Sancar

The Nobel Prize in Chemistry 2015 was awarded jointly to Tomas Lindahl, Paul Modrich and Aziz Sancar *"for mechanistic studies of DNA repair"* [26]. Dr. Sancar, specifically was awarded for mapping how cells repair DNA damage from ultraviolet light [27]. Deoxyribonucleic acid (DNA) molecules in the human body carries genetic instructions for growth, development, functions and reproduction. Unfortunately, DNA molecules are unstable and can be affected by exposure to ultraviolet light, toxins and pollutants. DNA replication is also a chemical process which is prone to random errors. Amazingly, life molecules have found a way to counteract both of these negative effects via a set of proteins that monitor the genes [28]. These proteins proof-read the genome and repair damage continuously. The three Nobel Prize winners mapped these fundamental processes at the molecular level, allowing scientists to understand the molecular causes of several hereditary diseases as well as the mechanisms of both cancer development and aging.

Aziz Sancar is a Turkish-American scientist who was born in Savur, Turkey in 1946. He completed his medical degree in Istanbul University, after which he served as a physician in the Turkish countryside. During this time, he became interested in biochemistry, specifically why bacteria, when exposed to deadly doses of UV radiation can suddenly recover when illuminated by visible blue light. To study this, he joined Claude Rupert at University of Texas in Dallas where he obtained his PhD in molecular biology in 1977. Interestingly enough, although he successfully found the photolyase enzyme that repaired the UV-damaged DNA during his PhD, continuation of this work was not funded and his three applications for postdoc positions were rejected. Not giving up, he furthered this work by taking up a laboratory technician position at Yale University School of Medicine. It was here that he started his work that earned him the Nobel Prize in Chemistry. His main discovery was that bacteria have two systems that repair UV damage, system i) an enzyme called photolyase and ii) three enzymes coded by genes that work in the dark system – *uvrA*, *uvrB* and *uvrC*. Remarkably, these enzymes can both identify UV-damage, excise the damaged DNA strand and repair the gap using DNA polymerase as shown in Fig. 9.

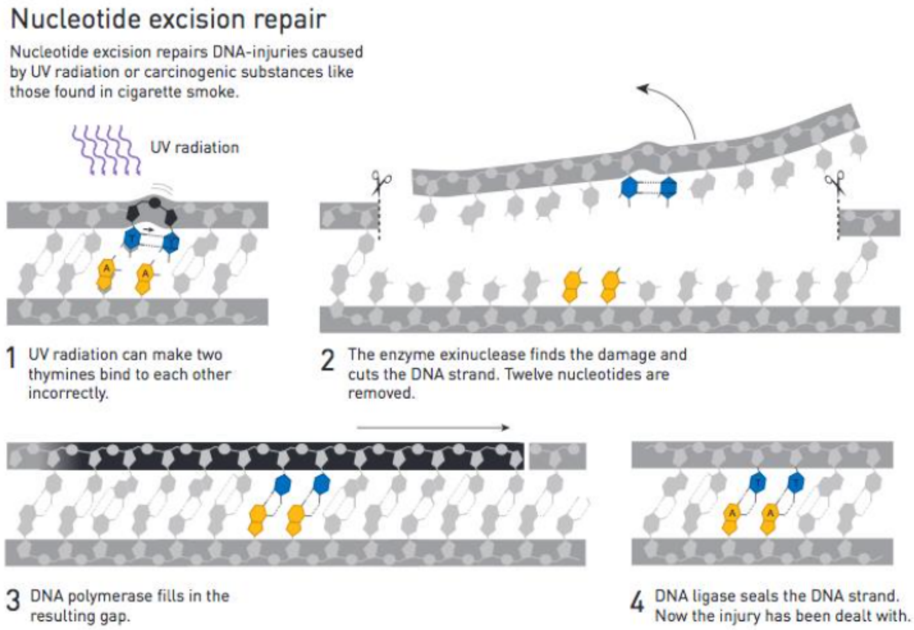


Figure 9: Aziz Sancar’s work on how the DNA repairs itself upon UV damage [28].

Aziz Sancar then was offered a lecturer position at University of North Carolina. He was elected as the first Turkish-American member of the National Academy of Sciences in 2005 and is also Sarah Graham Kenan Distinguished Professor at University of North Carolina at Chapel Hill. He and his wife, Gwen Sancar founded Carolina Turk Evi, a Turkish center located close to the campus of University of North Carolina that provides graduate housing for Turkish researchers and visiting scholars.

4. 21st Century Muslim Inventors

Hatim Zaghloul

Hatim Zaghloul is best known for his inventions used in digital communication systems, and among the most famous is the Wideband Orthogonal Frequency Division Multiplexing (WOFDM). Orthogonal frequency division multiplexing (OFDM) is a method of transmitting and combining digital data on different carrier frequencies. Using this technique, signals are modulated on separate carriers, kept orthogonal to each other to avoid interference and then are multiplexed before transmission. OFDM is widely used for wideband digital communications which are common in wireless networks, 4G mobile communications, DSL internet access and digital television. The drawbacks of this technique is that it is sensitive to carrier frequency offset and sampling clock mismatch. It also results in signals with large dynamic range, making it difficult to design hardware (RF amplifiers) for it. Together with Michel Fattouche, Hatim Zaghloul created and filed a series of patents on Wideband OFDM between 1992 to 2002 [29]–[31]. Wideband OFDM is a transmission scheme that is the basis of IEEE standard 802.11a. It is less sensitive to OFDM problems such as frequency offset, sample clock offset, phase noise and amplifier non-linearities. It can handle strong multipath and selective fading by using a powerful equalization scheme combined with a forward error correction scheme.

Hatim Zaghloul was born in Giza, Egypt. He completed his B. Sc. in Electrical Engineering in Cairo University in 1979. After a short stint in Egyptian Armed Forces and Schlumber Wireline Services, he continued his studies in University of Calgary where he earned his M. Sc. and PhD in Physics in 1985 and 1994 respectively. Upon completion of his PhD, he worked at several companies namely Wi-LAN, Cell-Loc, Solutrea, the last two in which he worked as the CEO. He founded IPL Media Inc in 2005 and is currently the Chairman and CEO. He also co-founded Hikmah Capital in 2012 [32], a Canadian based financial technology company that develops, acquires and invests in e-commerce and money management solutions.

Ali Javan

Ali Javan was an Iranian-American inventor and physicist at the Massachusetts Institute of Technology. His area of specialization was quantum physics and spectroscopy. He invented the first helium-neon laser that was capable of producing a continuous source of light. This technology allowed light to be coupled with fiber optics, revolutionizing surgery, telecommunications, created compact-disc players and supermarket scanners [33]. In 2007 he was ranked 12 on the Daily Telegraph's list of "Top 100 Living Geniuses".

His findings, done by a scientific team which included William Bennet of Yale University and Donald Herriott at Bell Laboratories in Murray Hill, New Jersey were a major breakthrough in the late 1950s [34][35]. Previously, ruby lasers were pumped using an intense light source, creating pulses of light. Instead, Javan used the principle of converting electrical energy to light output, by first storing the electrical energy in energetic He atoms in a pressurized tube which are agitated using electrical current, and are later converted into light. Helium was chosen due to its inert properties. Next, reflecting and parallel mirrors are used to both reflect and increase the intensity of light. The exponential increase in intensity of the reflected light creates a continuous, concentrated (less than half an inch) laser light beam. This laser also requires a low energy input of 50 watts.

Fig.10 Herriot and Javan with the helium-neon optical gas maser [36].

The success of gas lasers gave birth to fiber optics communications. Current data transfer rates in the range of Tb/s are made possible due to laser telecommunications via fiber optics. Fiber optics have rates that are tens of thousands times higher than microwave transmissions that rely on electromagnetic waves. Applications of lasers are vast, ranging from checkout scanners, printers, medical, interferometry and holography.

5. Summary

Adherence of the words of Allah in the Quran and the examples of the Prophet Muhammad s.a.w. made Muslims a force to be reckoned with in the early 8th to 15th centuries. Muslim dominance could be seen in all aspects, ranging from astronomy, physics, mathematics, technology and weaponry. There have been many write-ups on the causes of decline, which happened slowly but systemically in the past 500 years. Some scholars have attributed it to Muslim arrogance, close-mindedness and refusal to learn from the infidels, which were quickly advancing in terms of science and technology. Some have also attributed it to the suppression of women, which caused Muslim nations to lose 50% of their capable workforce, just due to their gender. What is perhaps worse, is that these suppressed women gave birth to generations of men who believed that power and strength can only be attained by subjugation of the weak. These comments need to be taken with a grain of salt as most criticism has been the eyes of Western historians. Needless to say, modern Muslims still need to accept the reality that the golden era of Muslim civilization has long left us for at least the past 500 years. The current generation of Muslims need to perform a lot of soul searching to recognize that there are indeed flaws to the implementation of the *Quran* and the *Hadith* in our daily lives that caused us to be in this sad situation. To emerge out of this current rut, we perhaps have to not only look at the causes of decline, but also analyze the positive qualities of Muslims that made them rise above the crowd. Based on our description of the Muslim scientists both in the past and at present, among their common characteristics are that all of them work very hard and are passionate in their field of expertise. Scientific achievements are often not accidental. It requires rigorous studies, tedious experimentations and development of theories. A good ecosystem is also necessary to allow researchers to flourish. These encompass administrative systems that allow freedom of research, high tech facilities and support of students or apprentices for the researchers. The Muslim inventors that lived during the golden age of Muslim civilizations were fortunate to be given all these supports. Modern Muslim inventors are not as fortunate, as can be seen from the examples that we have drawn from. Abdus Salam, Aziz Sancar, Ali Javan and Hatim Zaghloul were all successful in the Western world, which provided them the facilities and funding that allowed them to be great. The Muslim Nobel prize winners Abdus Salam and Aziz Sancar understood the feelings of isolation and difficulties faced by Muslims in the developing countries. Both of them went on to develop separate non-profit organizations that help to fund Muslim scientists stints abroad. Through these fellowships, talented Muslims are given a chance to do their research and network with researchers abroad. Hatim Zaghloul took his technological expertise to another level and founded a company that invests in e-commerce and money management solutions that takes into account the Islamic values and ethics when performing its business transactions. The success of these modern scholars also give us hope that all is not lost, and with proper planning and opportunities, Muslim inventors of today can still achieve something great.

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