

Medical History

The 'Art' of Science and Research: Jabir Ibn Hayyan Laid the Foundation.

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Abstract

This article identifies scientists' attributes and their approaches to innovation, sciences, research, and discovery as ascribed by Abu Musa-Jabir Ibn Hayyan al- Azdi - also known as Jabir Ibn Hayyan (or Geber) in the late 7th to early 8th century. Jabir was the first polymath to have set the stage for the Golden Age of Islam that lasted from the 8th to 12th century. In several of his books and research articles, Jabir identified researchers, scientists and scholars as the "artists" and their research methodologies and experimentation as the "art." A mastery or specialization in any given discipline that an "artist" pursues was termed by him as the "Majistry". The attributes that he proposed several centuries ago have since become the criteria, befitting the "art" of our present-day scientists and scholars. He explicitly detailed the attributes of an "artist" and also those who were recommended not to pursue sciences as a career. He described natural talent, innate propensity, the conquest of knowledge, deeper insights into Mother Nature, ingenuity, critical thinking, foresight, flexibility, adaptability, resiliency, persistence and selflessness as the essential ingredients of scientists and their success. Additionally, he also deemed funding, collaboration, partnership and community support to be pivotal. Rigidity – the "stiff neck," as he described it, and the lack of adaptability to be detriments to the 'art' of sciences. This article provides an eye-opening account of the scientific rigor that led to the Golden Age on the one hand, and on the other hand, attempts to reconcile the compatibility of modern sciences with traditional Islamic teachings. It also identifies the critical success factors that led to the rise of sciences in the Islamic world, which have since either been forgotten or ignored. We make recommendations throughout as to what needs to be done to revive the Golden Age of Sciences in the Muslim world.

Keywords

Jabir Ibn Hayyan, Golden Age Of Islam, Research Methodologies, Sciences, Innovation, Imam Jafar Sadiq (AS), Chemistry, Geber.



Introduction

The attributes that a scientist ought to possess have been highlighted in detail as per Jabir's written work in his First Book ("Of the Sum of Perfection, or the Perfect Magistry" – also translated in 1928 by Holmyard, E.J and Richard Russell in: *The Works of Geber*)¹. It is important to note that the word "Magistry" throughout Jabir's work implies two things; 1) he referred to it as nature having transmuted or curative powers and 2) Master-ship or authority in any given field of research or innovation. Holymard (1923)² provided a resounding endorsement of Jabir's works presented in his books: "Investigation of Perfection," the "Invention of Variety" and the "Book of Furnaces," as: "clearly written, definite language – free from enigma and allegories which disfigure so large a population of alchemical book and they contain much precise chemical information"^{2,3}. Moreover, Jabir has provided an extremely comprehensive framework vis-à-vis the classifications within various disciplines and branches of science, which was subsequently followed by other scientists of the Gold Age. This subject is, however, not the focus of the present article, but the reader is directed towards the two most recent articles written by Akyol (2018)⁴ and Montaziretabar and Feng (2020)⁵.

Many Muslim historians have 'disowned' Jabir's work because of either their ignorance or other reasons. Some non-Muslims, on the other hand, are reluctant to accept his scientific contributions arguing that it is unbelievable that an individual could have written so much (over 3000-5000 treaties) in one's lifetime. Then, there are those who defer a vast majority of Jabir's work to his students. To make academic dishonesty worst, many Greek, French and other European historians have created fictive characters with names similar to Jabir and attributed his works to those pseudo-scholars. Whether Jabir really authored all the work ascribed to him or not – is a debate beyond the scope of the present article; much has been written on this topic and the subject debated at nauseum^{1-3,6-12}. Through our extensive research and investigation into Jabir's work, we did nevertheless find unequivocal evidence that all Muslim

alchemists from the ninth century onwards declared Jabir as their master.

Furthermore, there is hardly a single book in Arabic in which he is not cited, or at the least, mentioned as the Father of Chemistry¹⁰⁻¹⁵. There is also irrefutable evidence that the Greek/Latin "Gaber," who has been revered as the father of modern chemistry, was actually Jabir Ibn Hayyan². Whether most written works ascribed to Jabir could authentically be attributed to him is debatable because the original Arabic text was either lost or burned by the Mongols when they conquered and rampaged Baghdad^{16,17}. In particular, the Mongols dumped all books that were kept in the largest Baghdad library into the Euphrates and the historian's state that the river water blackened with their ink for days. Such academic terrorism may have contributed to the loss of much Arabic text, thus undermining the authenticity of Jabir's original work. However, it is feasible that Jabir's successors in the Muslim world may have attempted to recapitulate his works from their memory, thus creating a myriad of writing styles with fragmented text – for which the English coined the terms like 'gibberish' or "gibber gabber." Be that as it may, it suffices to say that the works attributed to Jabir are worthy of him, and he is deserving of those contributions¹⁻³. It is also worth noting that the *Odyssey* was written by a multitude of writers using "Homer" as a pseudonym. Furthermore, we also know that Socrates did not write much; rather, his work was documented and subsequently reported instead by Plato.

In this article, we have focused primarily on the criteria that Jabir ascribed as a scientist's potential attributes and the nature of his adaptability characteristics. Towards the end, we have contrasted those traits to present-day academia, research, innovation framework – hoping that it will help the Muslim world. Furthermore, we hope that this will also serve as a wake-up call for the Islamic world – inciting a sense of awe, the reawakening of its heritage and the re-owning of their great minds who were once centuries ahead of the rest of the world. As Mazaik (2017)¹⁸ points out, the Muslims need not look to the West for all ingredients for the

rejuvenation of science and innovation as they already have the building blocks left behind by the Muslim scientists of the past. Furthermore, an extensive literature search challenges the notion that Islam has uniquely and inherently anti-science or anti-technology in all of its forms and manifestations. On the contrary, Huff (2003)¹⁹ points out that the scientific and technological knowledge creation in the medieval Islamic world greatly surpassed the West and China for centuries¹⁷⁻²⁰.

The primary motivators behind writing this article were several independent damning reports highlighting the abysmal state of academic standards, science and innovation in the Islamic world^{21,22}. Whereas the reports highlighted the factual state of affairs along with appropriate recommendations to mend the situation, they have not been taken seriously by the governments or the ruling class in the Muslim world²¹. On the other hand, these reports and their recommendations have left excellent researchers, scholars and scientists in the Islamic countries clueless about the strategic directions and the way forward. Considering their traditional cultural and religious bonds, they are discouraged by their respective authority not to invoke guidance from the "godless" Western world but rather seek inspiration from their own faith. This article makes such an attempt by identifying one of the greatest scientists of the Islamic world - hoping that we could extrude some wisdom and inspiration from the likes of Jabir Ibn Hayyan, who served as a beacon of light not just for Muslims but the entire human civilization.

Necessity and adaptive plasticity drive innovation and the entrepreneurial engine.

An innate propensity to adapt to their ever-changing environment is genetically ingrained in all animal species; however, more often than not, humans make those choices proactively. Adaptive changes allow all species, ranging from worms, fruit flies, bees and mammals, to survive and thrive within the confine of their respective evolutionary boundaries. With changes to their habitat and living conditions – either by choice or perpetual impositions, complex and intricate survival instincts

are invoked in all life forms. Parenthetically, the faster the change, the greater the adaptive plasticity. The unbound intellectual capacity ingrained in humans drives their zest and need for changes at a much quicker pace and with loftier aspirations than any other species. To keep up with the needs and demands of the forward-moving society, humans must change all the time. This could be done by creating new knowledge, its application, innovation in the form of novel technology development aimed at solving real-life problems or bettering the lives of fellow humans and other species.

In contrast to other animal species, over the years, humans have become adept problem solvers and the anticipators of future changes; these traits have allowed them to make predictions with expectations of the upcoming challenges. However, the changes are not always without risk, nor do the game changers possess an immunity idol when things go wrong. Whereas, on the one hand, such innovations can help improve the quality of life; on the other hand, they empower their possessor with uncanny dominance over their counterparts – both economically, culturally, socially and politically. A sense of superiority or competition which is ingrained in humans may also incite animalistic instincts. When devoid of moral codes of conduction, this may lead to exploitation and extortion of our knowledge, which could be used to subdue, harm or manipulate others. This, in turn, creates a wedge between the possessor of the knowledge power and the one whose is devoid of such wisdom, knowledge and technology.

As the leading nations' rulers sought global domination, they put their best and the brightest minds to invent novel products, find cures for diseases, and develop technologies for pleasure, comfort, and entertainment. These advances also predicted natural disasters, created better housing, recreation facilities, parks and infrastructure etc. which empowered them to explore the universe and the resources that it holds. These innovations changed the quality of their lives, living standards and provided them with better healthcare, state of the art academic institutions and research centers.

It goes without saying that the jobs created, resources fostered, and the wealth acquired through such technological breakthroughs allowed these superpowers to create greater wealth and global domination, which made the developing nations reliant on them for both intellectual and technological survival. One of the critical success factors behind their dominance is the system that invokes the expertise of 'think tanks' in order to orchestrate policies that are driven by a cohesive strategy under the auspices of a unified system – which rewards success accordingly. A successful nation selects and puts together its academies of scholars, provide them with resources and the infrastructure, thus setting them up for success. Moral and ethical codes are put in place to negate nepotism and fraudulent reporting. Achievements are incentivized, recognized and rewarded. This allows the entire system of education, research and innovation to emerge in partnership with both private funders and the industry, allowing them to take an idea from a concept to bench to bed and beyond in the market. A critical aspect is that the operators of the system have faith in the collective wisdom and are also the beneficiaries – both monetarily and with a personal sense of wellness and growth.

The system mentioned above serves as a core fundamental building block upon which the Western academic, research and innovation system - coupled with entrepreneurship is built, thus making them world leaders and economic powerhouses. The situation is quite the opposite in the third world countries – especially in the Islamic world where there is neither a system in place nor a sense of direction, purpose or the urgency to build anytime soon. The reasons for these inadequacies and shortcomings abound and maybe a topic of a separate discussion, but it suffices to say that the situation has not always been this way. Looking back at the Golden Age era when Muslims not only led the world towards innovation and taught what the Western world now knows in the domains of academia, research and innovation.

A question that often gets asked in the Islamic world is that if it were to emulate the science and innovation narrative perpetuated by a "godless" society, would that be reconcilable with Quranic teachings and the Islamic faith? Questions such as these were purported by Robert Reilly²³ and others to have ended the Muslim dominance secured during the Golden Age²³⁻²⁷. Reilly²³ states that the mindset which put breaks to Muslim conquest of knowledge, discovery and innovation had a lot to do with the hijacking of their faith by those who did not believe in independent thinking and deemed everything to be the Divine will. This mindset still dominates in the Islamic world, and for it, a Western education system, research acumen, scientific endeavours, and innovation-based drivers of the human civilization would contradict or threaten its cultural norms and Islamic teachings²³⁻²⁷. Notwithstanding these false perceptions, when one carefully studies the Quran, it draws our attention towards signs and not science; the latter is, however, contingent upon the former. This is, however, not just true for Islamic teachings but perhaps all faiths and religions. So, those who believe that science and the Quranic/Biblical teachings or Islamic traditions are contradictory to science could not be more mistaken, or perhaps do not understand their faith properly. If anything, no other religion or faith has ever emphasized or likely coined terms like "I'Im" better than the Quran. No other religion or ideology has emphasized the acquisition of I'Im (higher form of knowledge) than Islam. In the Holy Quran, the word I'Im has occurred in 140 places, while Al-I'Im (the seekers of knowledge) is cited on 27 occasions. Total verses where I'Im and its derivatives and associated words are used is 704 times. The aid of knowledge such as book, pen, ink etc., amount to almost the same number. Moreover, other words associated with writing have occurred in 319 verses. I'Im is referred to in many verses as "Noor" (unique light), and Allah is also described as the Ultimate Noor. It means that I'Im, in a general sense, is synonymous with the "light" knowledge and wisdom. Quran also claims that there is nothing in this universe, the knowledge of which has not been encapsulated within the Divine revelations of this book. It is

perhaps futile to discuss the issues of Islamic verses Western sciences; for science, it is sufficient that it is science. Scientific knowledge does not rely upon religious endorsement, nor do the religious beliefs seek out scientific ratification.

When Muslims of the 8th to 12th century embraced this concept as per the teachings of the Quran, their scholars were not only specialists in one discipline but also polymath and highly adaptive. They not only changed the world by being a beacon of light for the entire humanity – especially when the West was in the dark ages - but were also the creators of new knowledge. They developed novel technologies and made tremendous discoveries in all fields and disciplines. These discoveries did not make them give up their faith; rather, it was strengthened as they considered service to humanity a part of their religion. They set the standards and protocols for experimentation and the experimental design, which now forms the basis for Western systems of education, research and discovery. Whereas all scientists and scholars of the Golden Age²⁸⁻³⁷ contributed to what has since been emulated in the Western world, one of the first trendsetters among them perhaps was Jabir Ibn Hayyan¹³⁻¹⁵. The remainder of this article will highlight what Jabir described to be the attributes of scientists, how they should approach their respective disciplines, what role faith might play in a scientist's life, and how should the governments, the clergy, and society, in general, empower them to succeed. He also provided some tips on how academia and the research community should handle those who consider research and innovation as futile and contrary to human nature. We then highlight how the Western world likely picked up these recommendations and the fundamental scientific rubrics to shape its civilization; these being ignored - either intentionally or unintentionally by the Muslim world, thus leaving them far behind the rest of the world.

Jabir laid the foundation for the Golden Age of Science.

Jabir Ibn Hayyan's father, Hayyan al-Azdi was a druggist who came from the famous South Arabian

tribe of Al-Azd but had settled in the town of Kufa in Iraq. His father was most interested in political affairs and, as such, became an active supporter of the Abbasid family struggling to overthrow the Bani Umayyad rulers. He was sent for a political mission to Tus (near Meshed, Iran), and it was here that Jabir was born in 721-722. Soon after Jabir's birth, his father was captured, beheaded and impaled on a spear. Jabir, the orphan, was brought back to Arabia where he studied the Quran, theology and other subjects from a man named Herbic (we do not know his real name). As a young man, Jabir attached himself to the great religious teacher Imam Jafar Al-Sadiq (AS)^{2,38-42}, who held classes for about 4500 students over the years and is also known to have taught Imam Abu Hanifa (RZ) and many other young minds of that time. Imam Jafar's (AS) trainees then went on to seed the Gold Age of Islam. Whether Jabir was indeed a student of Imam Jafar (AS) has also been debated by some Muslims based on their biased views against the Prophet's family (PBUH) and others who quoted them. A careful review of all Arabic text of Jabir where he explicitly stated that "I owe my knowledge to the teachings of Imam Jafar (AS)" however, puts this question to rest. History tells us that the places where Imam Jafar (AS) took his classes there displayed a sign which read: "An orphan is not the one who loses his father, rather the one who is deprived of knowledge." In his classes, Imam Jafar (AS) taught subjects ranging from Fikh to philosophy to sciences³⁹⁻⁴². The most unconventional for that time was that Imam Jafar (AS) led open discussions and allowed his students from all walks of life and faiths to be open-minded in all disciplines and subjects. Imam Jafar (AS) was a member of the family of Prophet Mohammad (PBUH) and a true embodiment of the Quranic and prophet's (PBUH) teachings. He allowed his students not only to challenge his own faith and beliefs but also encouraged them to develop independent thinking, question the statuesque and to have an open debate on all subjects.

Imam Jafar (AS) used to teach in all fields of knowledge, but science as a subject held a very special place. He encouraged his students to write everything down and convert their text into books;

he forewarned them that a time was to come when those books and the knowledge contained within them would be much needed. According to Ismail al-Faruqi and Lois Lamy al Farouqi⁴³, it was in response to Imam Jafar's (AS) wishes that Jabir invented a kind of paper that resisted fire and an ink that could be read at night. He also invented an additive that, when applied to iron surfaces, inhibited rust and, when applied to textile, would make it water repellent⁴³. During Jabir's learning period, he studied mysticism and other occult matters under Imam Jafar's tutelage (AS), and it was from his classes that Jabir became interested in alchemy. During this period and his interactions with other students of Imam Jafar (AS), Jabir acquired encyclopedic knowledge – studying all branches of learning, including medicine. It is also important to note that Jabir started the concept of “experimentation” – to put theoretical knowledge to test through well-designed experiments³. Muslim alchemists from thereon have acclaimed Jabir to be their master¹⁰. There is hardly any book (Al-chemia) in the Arabic language in which he is not quoted or at the least cited as the father of chemistry. Richard Russell^{2,15} writes in: The sum of perfection that: “Jabir (Geber) was a polymath; a chemist and alchemist, an astronomer, an astrologer, engineer, geographer, philosopher, physicist, pharmacist and physician” – so were the other scientists of that time³⁶. In the present time, one will not be expected to find a single scientist as an expert in such diverse fields – both in the inter- and multidisciplinary domains. It is though important to note that with the advent of artificial intelligence, machine learning, robotic, biomedical engineering etc. the research and innovation drivers are dictating that most scientists and scholars be well-versed in the interdisciplinary arena; the expertise that was once a norm for the Muslims scientists of the Golden Age.

Jabir's teacher, Imam Jafar Sadiq (AS)², inspired his interest in interdisciplinary areas. Jabir writes in one of his books that: “my master Jafar Sadiq (AS) taught me about calcium, evaporation, distillation and crystallization and everything that I learned in Alchemy was from my master” (Vicki Marshal In: Royal Society of Chemistry)⁴⁴. Jabir often began his

articles by stating: “My Master and A'mine (custodian) of Wisdom” stated this or informed me about that (see - Ismaili History 384 FIELD, Dewji, 2016)⁴. Jabir is known to have written several hundred manuscripts and books; the most well-known among them were Book of Seventy, Philosopher's stone, the Sum of Perfection, investigation or Search of Perfection etc^{1-3,7,41,42}. In this article, we have opted to highlight a scientist's attributes and the critical success factors as per Jabir's assertions. However, in future articles, we will take up his authentic contributions and highlight the impact that they might have had on the present-day sciences.

What should be the attributes of an “Artist”/scientist?

As mentioned earlier, it is important to note that in all of his written works, Jabir referred to Scientists and Scholars as the “Artists,” however, in order to reconcile its literal meaning with the present time, we have replaced it throughout the article with the word “Scientist.” In two of his books/ manuscripts; (1) Of Sum of Perfection or (2) Of the Perfect Magistry, in Chapter III, he describes the attributes of a scientist (Artist), their responsibilities, the manner in which research should be conducted, and how might the research and discovery related activities be supported (see Holmyard and Russell, 1928 for original translation from Greek to English)¹.

Jabir writes that a scientist/scholar who does not possess natural ingenuity, an innate propensity for curiosity and talent coupled with conscience-based thinking must not take up this profession. He states that an innate curiosity credential and the ability to subtly scrutinize nature's principles are the fundamental attributes of a scientist. One must be curious about nature both in its properties and action; an individual devoid of these attributes cannot find the true source, the origin and the radix of this most precious science - he noted. Jabir went on to say that there are many with a “stiff neck” who are devoid of flexibility, ingenuity, insightful and endowed with meticulous examination traits. They lack comprehension of the fundamental knowledge and have difficulty understanding even

simple concepts; according to him: "they do not belong in the field of sciences"¹.

Then there are those who accept every intellectual "fantasy" that seduces them, and they believe in having already found the truth or an answer to any particular question. Notwithstanding the fact that their logic of inquiry is generally devoid of reason and fraught with error, their work does not conform to the fundamental principles of nature – he said. And the reason behind this shortcoming is that their mind, thinking and logic are often clouded with gaps in their fundamental understanding, comprehension and background knowledge. Those opportunistic scholars also hold prejudices and are either biased towards or against some concepts precluding them from seeing the truth and what nature might have concealed in it for them. Jabir implied here that all scientific endeavours should begin with a well-conceived, hypothesis-driven idea that is not contaminated with preconceived notions or personal biases. He encourages independent thinking and for one to design their research logically, with a clear rationale, well-defined objectives and fully anticipated outcomes. Unfortunately, this is not being taught in our research and academic institutes across the Islamic world, resulting in copycat research, poor quality publications with limited innovation potential.

Jabir goes on to say that then there are those whose thoughts vacillate, and they move from one project to another with a persistent change of heart, mind and direction. They tend to jump at projects believing them to be trendy without a clear understanding, the logic of inquiry duly considered and debated. They pounce at an opportunity, which they deemed trendy without a clear rationale. These "quasi scientists" leap again by leaving the previous activity unfinished and unattended to, and the cycle repeats throughout their careers. This fluidic, opportunistic nature and inconsistency disables and disempowers them from accomplishing anything in their careers, and whatever they do end up finishing is often incomplete, fragmented or wrong altogether. A take-home message that he left for scientists of all

times was that originality and persistence are two of the most critical success factors for an accomplished scientist.

Furthermore, he stated that then there are those who cannot see any truth or signs in nature except something that resulted from their fictive imagination - fraught with hallucinations, delusion and childlike imagery. He pointed his finger at those who regarded and treated science with contempt and considered it to be futile and useless; the science, in turn, condemns them and repels them away from its terrain – he stated¹. According to Jabir, vision and wisdom are the keys to a scientist's success, but that they must be based on clear rationale – rather than a concoction of their delusionary imagination.

Jabir then wrote that there are some who are slaves to their soul and admire science for the sake of and with the potential of making money. Notwithstanding that they appreciate science but are afraid or unable to change their mind; the nimbleness is a prerequisite for good science. Despite the fact that they consider science and research important, they embark on this path for the wrong reasons. Their greed and desire for money making through science do not generate wealth nor any satisfaction in their work. As such, the art of science does not come to them; "for how can he who is ignorant or negligent in search of science attain it so easily"¹. This is a profound recommendation applicable to the present time as well. We constantly remind our trainees that medicine, medication and drugs are for patients and people, not for profit – which incidentally comes anyways. On the contrary, these days, our industries and pharma are driven primarily by a financial mandate – spending money only in those areas that are deemed to yield the most return on their investment. The lack of service to society paradigm and the absence of empathy towards the masses have left us vulnerable to ailments such the COVID-19, Superbugs, cancer, neurodegenerative diseases etc.

In Chapter IV, Jabir talked about how to remove impediments and obstacles from pure sciences. He

pointed out that great and pure minds that are subservient to science are often hamstrung by extreme poverty, which takes away their zeal, zest, intellectual allowance and conquest of knowledge; these he considered to be essential for good science. They are either made to leave or postpone their endeavours in the eminent field of sciences. He pointed out that the lack of funding often drives many science loving scientists out of the field. Consequently, we miss out on a talent pool that could have otherwise served the discipline in a meaningful way. This is so profound and befitting for most developing countries, particularly for the Islamic world, which spends only 0.4% of its GDP on education, research and innovation^{7,20,21,24,25}. In addition to bright minds, good science also requires state of the art infrastructure, equipment, and facilities, which are under-funded in the Islamic world. Unless the government and other private and public sectors step up to the plate, things will likely not change in the Islamic world. Therefore, it is important that most developing nations begin to develop a framework that will help empower their great minds to succeed and seek independence from and its reliance upon other developed countries. It is important to note here that during the 1st period of the Golden Age of Islam, significant state funds acquired through "Zakat" and "Sadika" and other charities were diverted towards research and innovation²⁵. Moreover, rulers and other wealthy individuals patronized scientists for both prestige and financial benefits^{17,18,21,37}. In the second period, however, both the financing and funding shifted towards Madrasas, with the primary focus being on the creation of religious knowledge, thus leaving science hanging high and dry^{17,20,21,24,37}. We would like to give heads up that with the most recent pandemic, the world is heading towards de-globalization, thus reversing the "global village" trends - leaving the poor nations to fend for themselves. It is a wake-up call for the Islamic countries as well!

Jabir then goes on to say that there are many others besides the above, who are although curious men but they indulge in research for the worldly reasons while occupying themselves with a

"secular" mindset devoid of Divine considerations (or respect for "Mother Nature"). From such people, science withdraws itself, he claimed. He then went on to address the premised heads of states that science without a purpose is an impediment to its growth. From this passage, which was difficult to fully comprehend, we deduced that what Jabir attempted to say here was that there ought to be faith-based purpose to studying science; he later picked up this topic in more detail. It is interesting to note here that Jabir insisted that the purpose of science is to serve humanity, which has been mandated in the Divine revelations throughout history.

Who qualifies to be an "Artist/ Scientist?"

In chapter V of his book entitled: Qualifications of the Artificer (skilled craftsman or an inventor), Jabir poses the following question: What ought to be a scientist or a scholar's qualifications? He concluded his recommendations by stating that a scientist or a scholar should be an expert in his respective field, especially in nature's philosophy. He says that if a scientist does not possess yearning, thirst, and passion for knowledge, he will not acquire wisdom in the field of philosophy of nature. Such a deficit and shortfall can only be managed by seeking new knowledge, broadening the knowledge-base, and acquiring expertise that one requires for the task at hand. Therefore, an expert scientist must be helped by deep learning coupled with concerted efforts to acquire new knowledge and expertise.

In addition to their own efforts, the scientist must also be aided by others in the field to enhance the circle of their influence. Jabir noted that without a credible reputation, they would not be invited to scientific meetings and the gatherings of the experts in the field. At the scientific meetings, the academy of scholars could provide the individual with further critique identifying flaws and shortcomings in the experimental design. This could range from identifying the disconnect between the experimental design, the predictions made, and the data reconciliation with the interpretations drawn. Specifically, the insights gained, and the input obtained from others would allow the researcher to consider alternative

possibilities and strategies while identifying potential pitfalls that may have led to the misinterpretation of the data. Thus, the results obtained and the knowledge generated through his instinctive foresight must be authenticated by others. Jabir's take-home message here was that while science the ingenuity of the scientist helps science, the feedback provided by other experts may help identify the gaps and perhaps shortcomings in the completed work. This, in turn, provides rigour to the completed research through the peer review process resulting in the acceptance of the work by other experts. Unfortunately, acceptance of critique, the notion of seeking input and advice from others, is rarely invoked in the Islamic world. Moreover, the paucity of scientific meetings and the lack of a credible peer-reviewed process etc., have seriously undermined the academic institute's ability to produce rigorous and high-quality science. Such a close mindset would need to be opened up if the Islamic world is to reclaim its Golden Age era.

Another important attribute of scientists that Jabir highlighted was their persistence, and that one must not procrastinate or change directions when problems come affront. Lack of focus and persistence, he believed, were the worst enemies and hindrances to the creation of new knowledge and discovery. He went on to say that keeping the approach simple with appropriate tools ["one Stone (grinder) – one Medicine"]¹ was the key to the successful outcome of an experiment. He recommended that one should avoid complexity and keep the experimental design simple, but without compromising the essential necessities that were considered an important part of the original experimental design. He stressed that one must never cut corners – except to take out unnecessary steps and superfluties.

Next, he stated that one must be extremely diligent and exhibit patience in one's experimentation until the final product is generated and not to cut corners or allow shortcomings. This he exemplified by an individual who would lack the ability to generate new knowledge and to profit from a substandard product. This, Jabir suggested, would

lead the investigator to desperation and his reputation tarnished. It is also important, he stressed, that a scientist must know the theoretical background well, the fundamental steps and the principal radices pertinent to that field. Those who do not know or could anticipate the outcomes of an experimental design from the beginning will not find the ending fruitful. In my work, Jabir said, "I have explicitly stated those fundamental protocols and steps that anyone embarking on this journey would consider essential for that particular field"¹. Another important attribute of a scientist that Jabir eludes to and stresses is the temper management quality that one must never lose one's cool; this he pointed out would not only result in the destruction of their work but also their reputation. In our view, this is an essential attribute of a scientist – beyond one's technical expertise. The lack of temper management not only intoxicates the research environment but also discourages open and frank discussion, prevents constructive critique and leads to vindictive behaviour, which defiles the entire discipline of science.

He went on to say that a scientist working on a project should have both hindsight and foresight and must consider all potential possibilities, pitfalls and alternative strategies. They should also be vigilant and pay close attention while analyzing the results/data meticulously and carefully by being cognizant of the underlying causes and their effects. Moreover, they must ask why the results were the way they turned out to be and why things should be like the way that they were found to be? If any of these traits were missing in a scientist, then the person should not be operating in the field of sciences, he said.

Jabir Described Research Enablers: Importance of Funding and Funds Management Skills.

Jabir advised that one must manage one's money and funds carefully and not throw away the resources without due consideration as this will not only result in scientific failure but also leave the individual without money – poor and destitute. An important consideration to him was that the worst thing for a scientist would be that one reaches a point of a major breakthrough only to run out of

funds, abandoning the experimentation altogether and then have nothing to show for it ("miserable man as he is!")(1). He went on to say that those who lavishly and unwisely waste their whole treasure before reaching the end of the desired goals and do not acquire all appropriate instrumentation, chemicals etc., from the beginning are destined to fail. He said that this would bring them to the brink of collapse with disaster ensuring - having spent all their funds without reaping any benefits or paying off the incurred expenses. Most hurtful and terrible for such a scientist would be the loss of important science that he was in pursuit of, which would hurt society's progress. He pointed out that this need not be the case if one was vigilant both in the context of available funds and the time-lines/milestones calibrated for the entire scientific endeavour. A well-planned and the executed business plan would otherwise have resulted in understanding the holistic art of science and its principles, culminating in a fruitful outcome. The most profound thing that he noted was: "For this science agrees not with a man poor and indigent but is rather inimical and adverse to him"¹. This means that Science and scientific pursuits do not bode well for those who are poor - rather, it considers them its enemies and punishes them accordingly. The take-home message from this is that both experimental and financial planning go hand in hand to ensure that the scientific endeavours deliver the desired results within the resources available to deliver them. Accordingly, most western funding agencies require that the budget accompanying all applications be fully justified and time-lines identified in the submitted grant proposals.

Jabir then went on to say something crucial which distinguishes him from the present-day scientists. He said that a scientist (as mentioned earlier, he refers to them as the Artist throughout the book) must not consider his work to be "know-all and be end-all" or the final word. While the scientist should focus on completing the task at hand and seeking answers to the questions that he set out to answer, but the work must always be considered "in progress." He pointed out that "our art is reserved in the Divine Will of God, and is given to, or

withheld from whom He so wills. Who is Glorious, sublime and full of all justice and Goodness? And for the punishment of your sophisticated work, He denies you the art and lamentably thrusts you into By-Path of Error, and from your error into perpetual infelicity (misfortune) and misery. It is all because the Almighty is most angry and unhappy to whom (at the end of his work and labour), He denies the sight of truth. For such a man is constituted in perpetual labour, beset with all misfortunate and infelicity, loss, the consolation, joy and delight of his whole time, and consumes his life in grief without profit"¹. This is a profound statement from one of the greatest scientists of the Golden Age who brought his faith into scientific practice - humbling the scientists on the one hand, and on the other hand, encouraging the knowledge seekers never to consider their conquest as an endpoint. It also puts an end to the discussion of whether science and religion are reconcilable or not. If they could co-exist, an argument that has plagued the Muslim world's progress since the 12th century. We deem that here rests an important message for the Islamic World that indeed the conquest of knowledge ought to be their utmost priority but that Mother Nature only reveals its secrets to those who dare and care to ponder - regardless of their faiths and beliefs.

Jabir fights back against those who consider science either trivial or futile.

In the second part of his "First Book," Jabir goes on to identify the extrinsic factors, people and doubters who may be a hindrance, an impediment, an obstacle to science, or deny its importance altogether. He argues that it is important to nip their ineffectual critique, which is based on sheer ignorance in the bud, lest they stop the wheels of science from spinning. The anti-science people could influence those in the position of authority, thus creating roadblocks for the researchers and the science that they perused. It is also interesting to see in this chapter how Jabir openly debated the "evolution" of metals and minerals while citing biological phenotypic/transformational changes in various organisms. He sets the stage here to tackle the novice and the doubters of science to whom

he referred to as ignorant men and then addressed their concerns noted below accordingly.

A) The anti-Science Lobby.

While stating their arguments and concerns, Jabir said that the doubters argue that since the compositions and the combinations of various elements is so distinct and unique – “the way a monkey is so distinct from a man” that there is no way for any man to sort out their true composition in a laboratory. This is also the case for minerals, and since the scientists do not know how these mixtures came about in the first instance, it would be practically impossible to recapitulate them experimentally. The naysayers went on to argue that even if the compositions of various elements, compounds, metals and minerals were known, one would still be unable to deduce the exact amounts that brought them together. They argued that the composition of these metals or compounds would not be obvious to humans because the entire process took place at hidden places such as mines and caverns. Thus, it is not only that the scientists do not know their composition but that they are also unaware of how things initially came about. Moreover, since the formation of the compounds required specific temperatures, moistures, pressure – all unbeknown to the scientists - their claims of recapitulating them in a lab would be futile, trivial and unrealistic. As a follow-up argument, the naysayers argued that similar scientific endeavours had previously been perused by several wise people of the past; if it were possible to recapitulate nature, they would have succeeded. They further argued that the failure thereof is another indication that things that exist in nature cannot be experimentally reconstructed in the laboratory. Notwithstanding the fact that the philosophers have written about such possibilities but since there is no experimental evidence to back up their theories, therefore science itself is not a discipline to pursue. In other words, the rationale for their negation of scientific efforts was that since others failed to do it in the past, it would therefore not be feasible to reproduce compounds, metals etc., in the lab.

To build upon their argument, the naysayers further argued that the inability of the people of the past to recapitulate nature could not have been due to the lack of money as they were financially backed up by the kings and the princes of their time. They conclude that science as such is frivolous in its probation. Additionally, they further argued that science mostly relies upon observation, which in turn is contingent upon our senses, and since nature could not be fathomed by them, it would therefore be impossible to recapitulate things experimentally. If Mother Nature performed its magic openly, then one would see the transformation in front of one’s eyes. Since people have not seen an “oxen being transformed into a goat” or any other species to have transformed into a different one – either naturally or experimentally, these cannot, therefore, be reproduced by the scientists. Because metals differ so much in their unique attributes, how could a scientist transform one into another - especially if one does not know how any given species came to be in the first place? Moreover, nature perfects things in thousands of years and for the scientist to recapitulate them in a lab setting, they would need to live accordingly, which is not possible. It is, therefore, absurd, they said, that nature could be reproduced in a lab.

B) Jabir’s Response to Science Naysayers.

In response to their opposition to Science, Jabir said that indeed it might not be possible to recapitulate nature with all its complexities and the actions, but the principles that it invokes to execute them, and tracing those footsteps would most certainly be feasible. For the arguments that the philosophers and kings of the world have desired this science but could not find it, he said that it was not true. The wise men of the ancient past made significant observations, but they did not reveal their findings because of the opposition tendered by the ignorant and the illiterate people of their times. They neither demonstrated their work physically nor wrote down their findings and discoveries for the reason of incarceration by the ignorant. Having seen none of those previous efforts written up, the opposition judged them to be the ones who did not put any effort into

exploring the art of science. Moreover, the other reason for the people of the past not to have completed their tasks may be due to the fact that those scientists may have likely made errors in their experimental design and the ensuing judgement. While moving from material to biological sciences, Jabir said that the reason that we could not create life like that of the creation of metals or compounds in the laboratory is that the former requires the infusion of "soul," and we do not know much about its "proportions or composition." It is only the Highest and the Glories God who knows about the soul; how does the Almighty invoke His noble and perfect wisdom remains unknown to us (they ask thee concerning the soul, Say, the soul is from the Amr of my Lord, but you people have not been given knowledge but a little". The noble Quran.17:85). It, therefore, stands to reason that the perfection in oxen or a goat is the noblest and more occult than the perfection of a metal. As per the doubter's argument that one species does not change into another, Jabir replied that species could be transformed into other life forms. Specifically, when the individual of one species changes, it becomes an individual of another. For example, a worm that is both naturally and by nature of its mastery turns into a fly/ butterfly, which differs from its original life form through which it came into being in the first place. Similarly, a larva strangled into becoming a bee, wheat into danel, and a dog strangled into wormers by the putrefaction of ebullition are all examples of life-changing its form¹. Similarly, although we do not completely alter metals rather nature allows us to become its administrator.

To the argument that Mother Nature does its business by taking thousands of years and yet, humans live a short life, he said that it is true that we cannot imitate or recapitulate nature in its entirety, but it has set principles, which allow us to shorten the entire process significantly. Indeed, there was a time when the process was fast-tracked to create the entire universe in only a few days (he was perhaps referring to Quranic or Biblical verses where God is referred to have created the universe in only a few days). He went on to say that even for nature, it is not possible to move things or put

actions into motion at a much faster rate if those objects were devoid of such qualities, to begin with. He then stated that when we see a worm appearing from a decomposing dog, we do not immediately associate its sudden presence to a star being the source, rather the surrounding air or other causes wherein rests the potential source of its birth (mostly the flies). From these observations, we deduce the birth of this worm to be the work of nature as it finds out the most natural, efficient, effective and convenient source for its work – but this often remains unbeknown to us. For those who although believe in the importance of science but are unsure as to where to find it (spirits or the bodies), Jabir stated that science is not black magic, mystical, supernatural or occult, nor does it have any holly manifestations. Therefore, it must not be hidden from the wise. For the ignorant, they should be debarred from the entrance into the world of science, and this is made a general rule, he said.

In conclusion, Jabir provided a very explicit rationale, justification and set the criteria as to who should indulge in the art of science, what their attributes ought to be and how they should operate. He also logically addressed the concerns of those who considered science to be futile and identified the scientists whom he deemed unfit to reveal Mother Nature's secrets. In so doing, Jabir laid the foundation for the Golden Age of Islam, and it is his teachings, principles and criteria that is needs to be adopted by the Islamic world in order to bring back the glory days of Islamic scientific dominance. A testament to his suggestions and the recommendations are, however, evident in the manner through which the Western world has structured its research and innovation policies that drive their discovery engine.

Do Jabir's recommendations matter in the present time?

The education system in most developed countries is an inquiry-based and curiosity-driven curriculum that instils an awe-inspiring spirit in young minds from the early stages of their brain development. From their kindergarten to primary schools, they are encouraged to develop independent thinking, ask critical questions, make predictions, ponder

about nature and things around them, seek input, share and communicate their thoughts openly and without the fear of being wrong or ridiculed. As they reach high school and university, their core strengths in various disciplines get coupled with passion and they are allowed to pursue independent goals with fairly well-defined goals and problem-solving skills. They are also provided with the opportunities to conduct research in various areas to further foster and sift through their passion or even the change of heart. Their knowledge base, technical expertise and the ability to enhance personal, interpersonal and communication skills are further augmented during graduate school and postdoctoral training. At this stage, their mentorship by supervisors and others becomes more formal, and they begin to hear phrases like: 1) "It is OK to be wrong, 2) If you have done it right all the time, you are probably wrong, 3) If you fail to plan, you plan to fail, 4) One day in the library will save you three months in the lab, 5) If you wish to succeed, double the rate of your failure, 6) It is not what you have, rather what you do with what you have, 7) Absence of evidence is not the evidence of absence, 8) Service to society is the rent that you pay for being a part of it, 9) Mind is like a parachute, it only works when open, 10) The best way to make your dreams come true is to wake up". These trainees are required to test their hypothesis experimentally, present their completed work to committees and at international conferences, which helps them refine their thought processes further by identifying gaps in their logic and shortcomings in their conclusions. Such an opportunity not only enhances their scientific skills but also serves as an important networking exercise to promote collaborations and to create future employment opportunities. This is what Jabir described to be the traits deemed essential for a successful artist/scientist, though he did not lay down the steps formally as such. We do not know whether, during the Gold Age, there was any formal system of education that could have produced such polymaths the like of Jabir^{1-3,13}, Ibn Sina²⁸⁻³⁰, Al-Razi²³, Kindi³⁴, Ibnal Haytham³⁵ etc. but since there were so many like them, one wonders if our current education system is aimed more at producing specialists rather than generalists.

Having trained and groomed their young budding scientists early in their careers, most western countries then create a central funding system, which is aided by provincial agencies, private sectors, publicly supported charitable organizations, philanthropy etc., to help them succeed. Among the federally funded organizations we see in North America are the National Institute of Health (NIH) and Natural Science Foundation (NSF) in the (USA), the Canadian Institute of Health Research (CIHR), Natural Sciences and Engineering Council of Canada (NSERC Canada), British Medical Research Council (MRC, UK), Biotechnology and Biomedical Sciences Research Council (BBSRC, UK) and others. European Commission (EU) etc. Whereas NSF, NSERC and BBSRC like programs support discovery-driven research in fundamental sciences and engineering, the CIHR, NIH and MRC fund projects with health and translational outcomes. These and other similar investments have streamlined the process to provide financial support to researchers by making funding a part of their core budget, thus enabling steady, persistent, and competitive funding. This model also provides the opportunity to target funding towards those special needs and initiatives such as COVID-19, as per the need of the time and the circumstances. Special funding streams are created for salary support programs whereby the new investigators are also provided with start-up funds enabling the academic institutes to recruit star scientists to their academies. Such programs are, however, dwindling in most academic institutes in North America because of the funding crunches, but at some point, they did nevertheless help attract the best and the brightest minds to these countries. For instance, Canada had initiated a Canada Research Chair program that provided the excellent salary and start-up funds to attract several hundred - the best and the brightest scientists over the past ten years to Canada. These opportunities were targeted towards both young and well-established investigators, and they played a tremendous role in enhancing the research environment of its universities. Similarly, many provinces in Canada offer excellent start-up and salary packages to attract the best and the

brightest researchers, which helps them in creating centers of excellence. Unfortunately, no similar program exists in any of the Islamic countries – especially in Pakistan, whereby young investigators could similarly be attracted and supported by the government or the private sector. Such an initiative is essential as it not only attracts the best minds to various academic institutes but also helps to diversify the research acumen and expertise while preventing catastrophic inbreeding of researchers.

Now the question is, how did the above funding initiatives impact life in general for these nations from the health sector to the economy? The answer is evident when one examines the powerhouses that these nations have become on the global scale, whereas most of the Islamic world is struggling both at the academic and scientific fronts. The first order countries have diversified their academic institutes and curriculum to ensure that they create the future generation of highly qualified individuals fit to operate on the horizon of all future challenges for decades to come. These programs involve interdisciplinary research, biomedical engineering, precision health, artificial intelligence, machine learning, big data, robotics, gene therapies etc. and the disciplines are brought together by creating focused research institutes and centers of excellence.

To ensure rigour and quality control, at arm's length from the governments, are created granting agencies and committees, which oversee the adjudication process by invoking the expertise of specialist panels. The process, in general, is fair and devoid of prejudice, nepotism, and the excellence gets rewarded. The face to face committees are comprised of a chair, a scientific officer and at least three experts who review any given grant in-depth and provide their independent assessment. A consensus score (scale of 0-5 – Not fundable to Outstanding respectively) is then given and grants discussed in detail. All members of the committee are next asked to give their individual scores (they are allocated a 0.5 score either to score a grant up or down) based on the discussion that ensued and their impression of the grant. The scientific officer often captures all the discussion, and this feedback,

along with detailed comments of both referees, is then provided to the applicant – regardless of whether the grant is recommended for funding or not. For those proposals that are deemed un-fundable, the feedback helps the applicant to revise and resubmit their proposal in the next round. Such an anonymous process reduces bias, prejudice and makes the system fair and transparent. If a grant is funded, the monies are transferred to the host university with added overheads (20% of the total grant in Canada) to ensure that the university is also provided with some funding to support the day to day operation of the researcher laboratories (electricity, animal care facilities, water, infrastructure maintenance etc.). All funds and their dissemination are strictly regulated by the academic institutions to prevent misappropriation of funds or monies being directed away from the funded project. In contrast to Canada, where no grant funds can be directed toward the applicant's salaries, in the USA, the candidates are allowed to build in their 9-month salaries (except for summer months), and the academies are also allocated larger overheads – up to 50% in some cases. It thus compels universities to hire the best and the brightest minds who would attract funds to their respective academic institutes. In addition to supporting established researchers, Canada continues to support summer research initiatives whereby young and bright students interested in research are provided funding over a term of four months to work in a laboratory of their choice. These opportunities at times are also extended to high school students enabling them exposure to sciences at an early age. No similar initiatives exist in any of the Islamic countries, and as such, we miss out on capturing these young minds early and invoking a sense of awe and scientific curiosity in their minds.

In addition to research publications, classroom teaching and the training of the highly qualified individuals, some academic institutions in partnership with the private sector have created "Creative Destruction Labs," Science Parks or Innovation Alleys where young innovators pitch their ideas to various entrepreneurs, business groups, investments brokers etc. and are coached

so as to help achieve milestones that enable them to push technology from a concept stage to prototyping, experimental testing and then into the market. This also provides an opportunity for investors to get into a new venture at an early start-up stage, providing them with both an emotional and financial sense of ownership of the company. Programs such as this help generate innovators who end up developing novel technologies to move the course of human civilization forward. Unfortunately, no such credible scheme exists across the Islamic world. However, some efforts are being made in Iran, Turkey, Malaysia and Pakistan, but there is no credible and sustainable system in place to take projects to the finish line²¹. Iran takes the lead in filing patents, with Turkey not far behind although, such endeavours rarely result in product development and commercialization. For countries like Pakistan, there is no concerted national effort to support the filing of the patents and then securing them at the international level. The innovators and inventors also do not have access to private or public funds to take their idea from a concept stage to a product in the market. Unless the nation makes a concerted effort, notwithstanding a tremendous asset of young talent, to protect its future investment, it is highly unlikely that it would stand on its legs in the years to come.

Conclusion

Species adapt to changing environments, and this further accelerates the process of their future betterment. This "plasticity," adaptability and nimbleness allows humans to further climb the ladder of superiority. Having reached the pinnacle of its evolutionary hierarchy, the human species continues to expand its "neuronal real-estate" to better prepare for the future while solving real-world problems. For this, they would need to be proactive and harness the best and the brightest minds, and then set them up for success by providing adequate funding and the infrastructure. The success then becomes a habit for such nations - allowing them to prioritize their strategies rather than strategizing them. A critical mass of big picture thinkers, intellectuals, experts, scholars, philosophers, scientists, researchers and engineers

is then embedded under the umbrella of thinktanks and commissioned to solve real-world problems. Even though the methodology and the approach to solving real-world problems have changed significantly since the Gold Age, the principles, however, remain the same. Notwithstanding the fact that our value systems change with time, but the principles remain the same – like the laws of nature. In the present time, it may not be feasible or practical to go back to the Golden Age, but a blended model that could make accommodations for both religious, spiritual and scientific principals can be developed to ensure that the younger generation in the Islamic world does not have the false perception that modern sciences are irreconcilable with their faith. Nowhere else is one more encouraged to ponder than in the holy Quran; the book does not discriminate between those who do and those who do not believe in God; rewards are assured only for those who ponder. We would like to reiterate our message that: Look for Signs in Quran and not Science; the latter relies upon the former. Such were the recommendations given to us by Jabir and those who succeeded him, and therein lies our secret to the revival of the Gold Age of Islam.

Conflicts of Interest

None.

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