CHAPTER ONE

The Beginning

By the time science emerged as an organized activity in the Muslim world, the Islamic civilization had already experienced two profound revolutions. The first was an intellectual revolution of the first order, the second, a social revolution which brought three advanced civilizations into mutual contact in the Muslim world through a language that was to become the *lingua franca* of Muslim learning: Arabic. Both of these revolutions had far reaching consequences for the emerging Islamic scientific tradition.

The intellectual revolution was brought about by an intense meditation on the Qurʾān by the companions of the Prophet of Islam. In the course of one generation, the Qurʾān had transformed the entire range of human experience for the Arabs—from the rules of their language to the most mundane matters of daily life. Revealed to the "unlettered Prophet"[1] in "clear Arabic"[2] during the course of twenty-three years (610-32),[3] the Qurʾān not only contained a moral code and the fundamentals of faith, it also had an advanced technical vocabulary. This rich repository of technical terms, which revolves around the Qurʾānic concepts of life, death, resurrection, prophethood and the moral response of the two sentient beings[4] to its message, provided the first conceptual framework for the Islamic tradition of learning.

The first to emerge in Islam were the religious sciences. During the life of the Prophet, the nascent Muslim community had recourse to him for all their spiritual needs. But after his death, the foremost problem faced by the community of believers was to know how to know God. The path to this knowledge, outlined in the Qurʾān, had to be elucidated. The person most

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1. *Nabīyun ummīyun*, Q. 7:7.
2. ʿ*arabīyun mubīn*, Q. 16:103.
3. The exact date of the first revelation is almost impossible to ascertain. Many historians favor 21st day of the month of Ramaḍān, 13 years before the Hijra, when Prophet Muḥammad was 40 years, six months and 12 days old (39 years, three months and 22 days according to lunar calendar). This is based upon the reports that the first revelation came on a Monday, in the month of Ramaḍān. This corresponds to August 20, 610 CE. Other reports suggest the 7th or the 17th day of the same Ramaḍān.
4. Humans and *Jinns*, see Q. 6:128, 130; 51:56; 72:1.

eminently qualified to do this was the Prophet himself but after his death, this responsiblity had to be shared by those who were the most learned. The work of these men and women gave rise to the emergence of the sciences of the Qurʾān (*ʿulūm al-Qurʾān*), which included, among others, the science of its recitation (*ʿilm al-qirāʾat*), exegesis (*ʿilm al-tafsīr*), and jurisprudence (*fiqh)*—the queen of Islamic sciences.

This was followed by the emergence of various sciences related to the preservation of the sayings and deeds of the Prophet, Ḥadīth: *ʿilm al-rijāl*, (science of biographies), *ʿilm al-ansāb* (science of genealogy) and *ʿilm al-tārīkh* (science of history). These religious sciences provided the intellectual context and some elements of the methodology that was later used by natural sciences. The key elements of this methodology were an uncompromising adherence to truth and objectivity, a respect for corroborated empirical evidence, an eye for detail and a refined taste for proper categorization and classification of data. It was only after the Qurʾānic sciences had been firmly established and earliest collections of Ḥadīth had been compiled that the Islamic scientific tradition emerged. But more than the mere chronology, what is important here is the fact that the scientific tradition that was to remain the most advanced scientific tradition anywhere in the world for the next eight centuries, arose from the bosom of a tradition of learning that had been grounded in the very heart of the primary sources of Islam: the Qurʾān and Ḥadīth.

The Intellectual Milieu

Before the advent of Islam, Arabs had no science except for the traditional Bedouin knowledge of astronomy and medicine. There were only a few among them who could read and write. But they excelled in poetry and their memory was legendary. Arabic was already a sophisticated language but it did not have scientific technical vocabulary. The rules for Arabic grammar were first formulated by Abūʾl Aswad al-Duʾālī (d. 70/688-9), who flourished at Baṣra. According to the legend, it was ʿAlī ibn Abī Ṭālib, the cousin, and later, the son-in-law of the Prophet and the fourth and the last of the four rightly guided caliphs (r. 36-41/656-661) who is said to have told al-Duʾālī to write a treatise on Arabic grammar based on the tripartite principle that the parts of speech are three: the noun, the verb and the particle.[5] This he did and Arabic grammar later developed on the basis of

5. There are different opinions about Abūʾl Aswad's name, geneology and *nisba* but all sources agree that he was an eminent *Tābiʿī*, a partisan of

this principle, initially in Madinah, Kūfa and Baṣra—the three earliest centers of intellectual activity in Islam.

Arabs viewed the level of civilization of a person or a nation on the basis of linguistic skills. The purest Arabic was spoken by the Bedouins of the desert and initially it was the extraordinary power of the Arabic of the Qurʾān that baffled the Makkan contemporaries of the Prophet; the Qurʾānic Arabic was beyond anything they had ever heard. Its rhythm, its evocative power, its tremendous force and its unearthly syntax was so enchanting that even those who did not believe in its message used to go where it was being recited, merely to listen to its extraordinary discourse in a language that used the alphabet of their own language but that transcended its bounds by a mysterious mechanism.[6]

But more than the sheer linguistic power of the Qurʾān, it was its urgent invitation to act that provided the earliest stimulus for reflection on nature. The Qurʾān contained a large number of verses that called attention to the harmony, symmetry and order present in the natural world. It drew attention to the regularities of the planetary motion, it asked its readers to reflect on the watercycle, on the alteration of the day and the night, on the way certain trees bifurcate and others do not, though they are rooted in the same soil and receive the same nutrients. It asked the faithful as well as the non-believers pointed and enigmatic questions: What was there behind this astonishing order in the universe? Who was responsible for the functioning of such a grand system? Who had established the order that allowed them to benefit from various processes present in the natural world?

This invitation to reflect on nature was such an insistent theme of the Qurʾān that no one could ignore it, not even those who did not believe in its message. One cannot over-emphasize in a work of this kind the central position that the Qurʾān holds in the development of the Islamic scientific tradition. In fact, every doctrine or every branch of knowledge that appeared in the Islamic polity traces its roots back to the Qurʾān. It would not be wrong to state that the Qurʾān is the foundation upon which everything Islamic is built. This revealed text is the primary source, the

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ʿAlī ibn Abī Ṭālib, under whose command he fought at the battle of Ṣiffīn. *Wafayāt*, vol. 2, pp. 535-9; *Fihrist*, pp. 87-90.

6. For example, the reaction of ʿUmar ibn al-Khaṭṭāb and Walīd b. al-Mughīra, two Makkans who knew how to read and write and who had a very developed literary sensibility; both felt utterly powerless against the power of the Qurʾān. The former accepted the message of the Qurʾān, the latter called it magic and sorcery.

essential textbook, not only of the religious sciences but also of all other branches of knowledge that emerged in the Islamic civilization. It is the secret spring of the Islamic Weltanschauung, the very heart of the civilization inspired by this faith which made its first appearance in a remote desert, far from the main currents of other civilizations. We will see how the Qurʾān linked the events occurring in nature to its central message in the next chapter; for now, let us briefly reconstruct the intellectual milieu of the early Muslim era and place the emergence of the Islamic scientific tradition in a broader historical context.

The technical terminology that came into existence as a result of a fervent and profound meditation on the message of the Qurʾān by the first generation of Muslims was employed in the *tafsīr* (exegesis) literature. This was an attempt to understand the precise and multi-layered prose of the Qurʾān. In this process, the new technical terminology was defined in minute details. Grammar, rhetoric and the study of the pre-Islamic Arabic poetry also developed primarily as linguistic aids to the interpretation of the Qurʾān. Thus, before the emergence of the Islamic scientific tradition, certain fundamental concepts, which had direct relation to the study of nature, had already been defined from the Qurʾānic perspective. This included the very notion of knowledge (*al-ʿilm*) and its related concepts—gnosis (*māʿrifa*) and comprehension (*idrāk*).

But the Qurʾān could not be interpreted merely on the basis of linguistics; it required an inspired heart, a profound faithfulness to its main function (guidance), an indefatigable fidelity to the Law (*Sharīʿa*) and a detailed and comprehensive understanding of the life and sayings of its first bearer and interpreter—the Prophet of Islam. Thus it became necessary to recall, recollect and use the sayings and actions of the Prophet for a better understanding of the message of the Qurʾān. The greatest scholars of Islam during this early period were primarily linguists, exegetes and jurisconsults (*fuqahāʾ*) who dedicated their lives to the patient study and interpretation of the Qurʾān and the Traditions of the Prophet (Ḥadīth) for the urgent needs of the Muslim community. They shaped the emerging intellectual milieu of the Muslim world in such a manner that the vision of Islam could be translated into a tradition of learning that was accessible to all and that could absorb new branches as it grew.

Not surprisingly, at the heart of this tradition of learning was the Qurʾān. Committed to memory in childhood, the Qurʾān regulated every event in the life of the Muslim community; it provided maxims to reflect upon, it nourished the hearts of the believers, it guided the scholars in their search but it also guided those who could not even read the text by a method that directly affected the spirit. This initial flowering of the Qurʾānic sciences created the foundations of Islamic tradition of learning upon which was built the study of nature.

The Qurʾānic Data

The resources available to the emerging Islamic scientific tradition were not laboratories and instruments but a grand metaphysics of nature, a framework for inquiry and a language equipped with the technical terms needed to express the results. The Qurʾān restored to the Arabic words their true character by stripping all illusions produced by the fantasy of pagan poets. Thus consecrated, the Arabic of the Qurʾān referred everything back to the direct and sovereign divine influence. The Qurʾānic name, *ism*, conferred to the thing its reality (*ḥaqīqa*) according to the divine knowledge, its objective existence (*kawn*) in creation and its legal value (*ḥukm*) amongst created beings. This minting of the name (*waḍʿ*) simultaneously placed the thing so named in its proper domain among things and established its ontological dependence on the Creator.

When the scientific tradition emerged in the Islamic civilization, its initial technical terms came from the Qurʾān and they referred back to the Qurʾānic usage, establishing a fundamental congruity between their scientific usage and their Qurʾānic meaning. The astonishing fixedness of the Arabic roots helped to identify the radicals of the Arabic verbs even in their most derivative form. In all fifteen verb forms, the verbs remain perpetually connected to their living source of fundamental meaning derived from the consonants. This not only helped in the compilation of Arabic dictionaries on a scientific basis but also established a semantic link between the technical terms and the language of revelation.

The conceptual framework that emerged during the early years of Islamic scientific tradition also used the resources of the Arabic language which were first developed for the study the Qurʾān. Arabic morphology had investigated different aspects of each root word as actualization of divine action. It had granted maximum energy to the imperative mood of the verb. All verbal forms were analyzed in composition, classified in their respective logical order (*taqdīm wa tāʾkhīr*), and examined in their reciprocal situations with respect to the one who utters them (*al-mutakallim*, the first person), the one upon whom they call (*al-mukhāṭib*, the second person) and the absent one of whom they speak (*al-ghāʾib*, the third). They were evaluated in respect to their degree of actualization in time: *māḍī*, the perfect, the action perfectly decided, realized and *muḍāriʿ*, the aorist.

This structure of language was affected by the Qurʾānic usage of words through the very process of ordering of ideas. This had a direct relevance to the terminology that was used in the Islamic scientific tradition. For example, reflecting on the fourteen consonants that are spelled like isolated letters (*al-ḥurūf al-muqaṭiʿāt*) which appear at the beginning of twenty-nine chapters (*sūwār,* sing., *sūra*) of the Qurʾān,[7] early commentators and grammarians established the basis for the emergence of the doctrine of *ishtiqāq al-akbar*, "superior semantic", codified by Abū ʿAlī al-Ḥasan b. ʿAlī al-Fārisī (d. before 370/980-81).[8] This bold etymological leap was an attempt to fix, outside of time, the idea-type of which such and such a phenomenon should remain constantly a sign. These isolated consonants were also the inspiration for the emergence of the science of the philosophical alphabet (*jafr*) that the sixth Imam, Jāʿfar al-Ṣādiq (d.147/765), is said to have been the first to apply to the Arabic alphabet. Jābir ibn Ḥayyān (d. *ca*. 160/777), one of the first major figures of Islamic scientific tradition whose works have survived, and its most celebrated alchemist, was to make ample use of these resources of the Arabic language in his "Theory of Balances", as we shall see toward the end of this chapter.

The Social Revolution

The social revolution which was to affect the emerging Islamic scientific tradition in a decisive way was brought about by the rapid expansion of the Muslim world into the regions held by three advanced civilizations: the Persian, the Egyptian and the Byzantine. This expansion started soon after the death of the Prophet of Islam in 11/632 and, over the next century and a half, produced a phenomenal intermixing of a large number of people of different races and religions in an ever-expanding geographical state. The swiftness of this expansion, its cosmopolitan nature and its sustained force was to transform the social relations and give birth to a creative energy that would transform all spheres of human activity. This social revolution also helped the nascent Islamic scientific tradition to incorporate into its body almost all extent works of the Persian and Hellenic science during the

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7. These 29 *sūwār* are: 2, 3, 7, 10 to 15, 19, 20, 26 to 32, 36, 38, 40 to 46, 50 and 68. The 14 "disjointed letters" (*a, l, m, ṣ, r, k, h, y, ʿ, ṭ, s, ḥ, q, n*) come in 14 combinations of either one, two, three, four or five letters.
8. His advance grammar, *Kitāb ʾabyāt al-Iʾrāb* and its commentary, *Kitāb Sharaḥ ʾabyāt al-Īḍāḥ*, influenced all subsequent works of Arabic grammar. See *Fihrist,* pp. 139-40.

course of three centuries through one of the most startling translation movements in history. This movement, which began in the middle of the eighth century and ended in the middle of the eleventh century, was patronized by a large number of individuals and institutions.

The expansion of the geographical boundaries of the Muslim world was to continue for at least eight centuries but its first two phases stand out as two rapid waves that brought a large area under Muslim dominion. The first took place during an eighteen-year period between 11/632 and 29/649; the second between 74/693 and 102/720. Both of these expansions are important for placing the Islamic scientific tradition in its social context. During the first wave of rapid expansion, which started in the very year of the death of Prophet Muḥammad, first to be conquered was southern Mesopotamia (12/633); two years later Damascus was under Muslim control (14/635); the same year Persians were defeated at Qādisiyya (14/635). The following year (15/637), Byzantines were defeated on the River Yarmūk; in 16/638 Persians were again routed at Jalūla and Ctesiphon, the Sassanian capital was conquered. During the same year, Kūfa and Baṣra were established as garrison bases (*amsār*); both cities would become intellectual centers of the early Muslim centuries. Jerusalem was conquered in 17/638; this brought a large influx of Jews and Christians into the Islamic milieu. By 19/640, all of Persia had been conquered; Egypt fell in 19/640; the same year Armenia was attacked; the next year (20/641), a companion of the Prophet, ʿAmr b. al-ʿĀṣ, conquered Babylon. In 22/643, Fusṭāṭ was founded on the east bank of the river Nile, alongside the ancient Greco-Coptic township of Babylon.[9] In the following year (23/643), Tripoli was conquered; in 26/646 Alexandria was finally captured (it was previously besieged in 22/642 and 24/645); in 29/649 Muslims had a powerful navy which was fighting against Byzantines; the same year Cyprus was conquered.

The second wave of expansion between 74/693 and 102/720 stretched the boundaries of the Muslim world into the very heart of Europe. In 74/693, the Muslim army defeated Justinian II at Sebastopolis, Cilicia; the next year Armenia was conquered; in 78/697 Muslims were in Carthage. In

9. Traces of Babylon are still preserved in the ramparts of the Qaṣr al-Shamʿ. A bridge of boats linked it to the city of Giza (al-Jīza) on the west bank of the Nile. The name, al-Fusṭāṭ (*lit.* the tent) was given to the city because it was founded on the spot where ʿAmr b. al-ʿĀṣ had pitched his tent during the siege of Babylon. The remains of both al-Fusṭāṭ and Babylon are now part of Old Cairo.

92/710, four hundred Muslim soldiers had landed at the southern most tip of the Iberian Peninsula under the command of Ṭāriq b. Ziyād; two years later, all of Spain, except for a strip of territory in the northwest of the peninsula, had been conquered. By 94/712, Muslims had established permanent rule in Sindh and Samarqand, the latter was to become an excellent center of Islamic science. In 99/717, a vanguard of the Muslim army had crossed the Pyrenees into France, seizing Narbonne; by 102/720, Muslims were well settled in Sardinia.

For our purpose, the significance of this rapid expansion lies in the fact that the newly conquered lands brought Muslims in direct contact with the most ancient centers of learning in the midst of a social revolution that involved large-scale displacements and resettlements of a large number of people, conversions and mixing of races and faiths along with the establishment of new garrison cities. The development of new relations between people of different races and religions played a key role in the direction taken by the Islamic scientific tradition during its early days. The newly established contacts between Muslims and the Syriac-speaking Christians on the one hand and between Muslims and the Zoroastrians on the other were instrumental in the emergence of a translation movement that would bring a large number of Persian and Greek scientific texts into the Islamic scientific tradition. We will explore the impact of the translation movement in the third chapter.

It is useful to situate the emerging Islamic tradition of learning in its proper social context; after all, we are dealing with real men and women who lived their lives in relation to others and in a given time and place. We have already mentioned the two powerful conquest waves that swept through the ancient centers of learning, but what does it really mean? How could small armies of Muslims, originating in the city of Madinah, hold a territory so vast, belonging to so many races, cultures and religions? And what were the means of transfer of knowledge from the ancient centers of learning to the nascent Islamic tradition?

Most narratives of Islamic history ignore the remarkable process of social revolution that accompanied this conquest. They record the heroic deeds of individuals, details of battles and encounters of generals but they fail to bring into focus hundreds of thousands of men and women who lived in Ray, Khurāsān, Samarqand, Bukhāra, Córdoba and hundreds of other cities and villages; real human beings who could not be conquered overnight. Armies came and went but these men and women who lived out their lives in their localities did not come into the fold of Islam just because a famous general, having defeated the army of their general, had passed through their town on his way to the next campaign. In order to have a glimpse of the social revolution that accompanied this conquest, we must perceive these changes at a local scale, in very ordinary terms. True, we cannot leave out the heroic deeds and the high drama altogether for that is the stuff of history, but in order to understand the emergence of a new tradition, we must concentrate on a much smaller section of the bigger picture.

The post-conquest Muslim world during the first century of Islam was made up of geographically dispersed and racially diverse communities in which the Arab Muslims constituted the ruling stratum of a multilingual, multi-ethnic but overwhelmingly non-Muslim population. A vast majority of this overwhelmingly non-Muslim population lived in villages, some of which were in such remote areas that the news of the Muslim conquest could only reach there months or even years after the capture of main cities. Hence, whereas the conquest of land was a rapid process, the process of conversion to Islam was not; it took place gradually and naturally.

On the scale on which we wish to construct this picture, we must see this social revolution in small details. What did the Arab armies see when they arrived in new areas? They saw animals, birds and insects which they had never seen before. They saw new methods of irrigation, the use of new fertilizers, new crops and new fruits. They met with new warfare techniques, they encountered new technological devices, they saw bridges, dams, roads, they faced new manners of fortification and new methods of military communications. They saw beautiful ceramics, inks, pigments and embroidered artifacts. Most of these diverse things varied from country to country: what Samaqand offered was different from Egypt and what they found in Sardinia was different from what awaited them in Merv.

In the course of a century, all of these diverse and varied crops, methods and techniques became part of the Islamic civilization which spread over the newly conquered lands. The diffusion of new crops— such as rice, sorghum, hard wheat, sugar cane, cotton, watermelons, eggplants, spinach and many others—in various parts of that large empire meant that new techniques had to be developed for their cultivation in areas where these crops had never been cultivated. This also meant that thousands of men and women learned the use of new cultivation methods, they used new manures, they developed new irrigation systems, they increased their number of crops, making use of the seasons during which time the land had traditionally laid fallow. This meant a completely new rhythm of life which affected their work hours, their family and social relations and their sources of income.

This social revolution also facilitated mobility of people of different racial backgrounds at a scale never witnessed before. It was accompanied by a massive transfer of seeds, pigments and hundreds of other items over a large area. A process of urbanization also accompanied this social revolution. The new urban centers produced by this social revolution had to be provided with civic facilities, water, food, vegetables and sundry other things. This meant building of new dams, water channels, roads and a system of communication.

Throughout this period of unusual creative energy, there was one unifying thing: the Qurʾān, its text having been given a definitive orthographic form during the reign of the third caliph, ʿUthmān b. ʿAffān (r.24-36/644-656). These rapid demographic and social changes also created new challenges of diverse nature. Most of the people in the newly conquered lands did not speak Arabic. How were they going to understand the message of Islam? With the rapid expansion and intermixing of races, new juridical and doctrinal issues arose which could not be settled on the basis of precedence found in the practice of the Prophet or on the textual basis found in the Qūrʾān. It was during this early period of the ever-expanding caliphate when its administrative center moved from Madinah to Damascus in 41/661 that the legal schools started to take definite form. The first of the four major legal schools into which Muslim jurisprudence eventually crystallized was that of Abū Ḥanīfa who used deductive extension of jurisprudence by means of analogy (*qiyās*) and insisted upon the right of preference (*istiḥsān*) of a ruling suited to local needs. The other three legal schools were founded by al-Shāfiʿī (d. 205/820), Mālik b. Anas (d. 179/795) and Aḥmad b. Ḥanbal (d. 241/855).

Nor was this newly emerging social milieu a cohesive entity, and this, too, had profound consequences for the Islamic scientific tradition. The Islamic community was founded on the basis of a series of conditional contractual allegiances (*bayʿa*, *lit*. the squeezing of hands). First, there were the two ʿAqaba contracts, which formed the political and social foundation for the Prophet's migration to Yathrib (later to be called Madinah). Then there is the *Ṣaḥīfa Madinah,* in 48 articles, which is considered to be the first written constitution of the Islamic state. In both, the Prophet appears only as an overseer of the affairs of the Community of Believers, *umma*, without any legislative authority, the legislative magisterium (*amr*) being reserved for the Qurʾān alone. The executive power (*ḥukm*), an imperium, canonical and civil, belonged only to God; the role of the Prophet being only that of a facilitator. "I have received the command to wage war against men until they proclaim publicly: 'there is no deity except God'," he said, "once they announce this, their blood and their possessions become sacred to me by virtue of belief and their judgment belongs to God."[10] It was not up to him to probe the hearts of others; he had only come as a "warner and as a bearer of glad tidings".[11]

The prophetic authority was, thus, entrusted to Prophet Muḥammad by God, in the service of the Qurʾānic Law and his political role was based on a formal contract with the community of believers, through their contractual allegiance literally performed on the hands of the Prophet by their representatives. After the death of the Prophet, this contractual oath was made with the first Caliph, Abū Bakr, by the leaders of various tribes at the gathering held at Saqīfā Banū Sāʿda on the day of the death of the Prophet. Abū Bakr received this authority as *Khalīfa tul Rasūl*, the vice-regent of the Prophet. At the death of Abū Bakr in 13/634, the choice fell on ʿUmar b. al-Khaṭṭāb, allegiance was sworn on his hands as *Amīr ul-Muʾminīn*, the leader of the believers. On 26 Dhūʾl-Ḥijja 23/3 November 644, as he was leading the morning prayer, Abū Lūʾlūʾa, a Christian slave of al-Mughīra b. Shuʿba, then governor of Baṣra, attacked him with a poisoned knife.[12] On his deathbed, ʿUmar constituted a *shūrā* (council) to choose his successor. Three days later, he died on the first day of the new Hijra year 24/644. Through the consultative process, the choice of leadership fell on ʿUthmān and, once again, the leaders of various tribes swore allegiance to him.

But the choice of the leadership of the community became an issue in 36/656, at the time of the assassination of ʿUthmān—a schism from which Muslim polity never really recovered. It was this deep chasm that resulted in shedding of blood of Muslims by Muslims and that raised a fundamental question for which no simple answer could be found: Who was qualified to lead the community? The tension was heightened in 37/657 when two Muslim forces stood against each other at Ṣiffīn. The contest for the caliphate between ʿAlī, son-in-law of the Prophet and Muʿāwiya, the governor of Damascus and later the founder of the Umayyad dynasty, had

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10. *Bukhārī*/40/34.
11. *Bashīr wa nadhīr*, *cf.* Q. 5:19; 7:188; repeated many times.
12. Abū Lūʾlūʾa, whose first name was Fīroze, had complained to him about a tax against him and ʿUmar had not complied with his request for a waiver, which he thought was not justified.

become a complex affair in which most of the prominent Muslims took sides with one or the other contestant. Swords were drawn but when ʿAlī restrained himself and consented to arbitration, a section of his army mutinied, alleging that his consent to arbitration meant that his claims to caliphate had not been legitimate. The mutineers, who became known as the *Khawārij* (Khārijites or Secessionists), raised fundamental questions about the basis, limits and qualifications for the political authority. Their extreme views set them apart from other Muslims. They held that a Muslim who committed a grave sin (*kabīra*) would cease to be a Muslim and if he were the caliph, his blood would become lawful.

The *Shīʿa*,[13] who had pledged ʿAlī their unquestioning support because they recognized his right to caliphate on the basis of his kinship to the Prophet, challenged this view, as did the *Murjiʿa*,[14] who disagreed with the Khārijite criteria for judging the belief of another Muslim on the basis of outward conformity to Law. They stressed that the submission and love of God was the foundation of belief, not the acts of piety. Should a believer commit one of the grave sins, but still believe, it would not impair his or her faith. They stressed that the ultimate verdict should be left to God; political authority should not be questioned on theological grounds because, in the final analysis, it belongs to God alone to determine the nature of the faith of every Muslim. They agreed with the Khāijites that any pious Muslim chosen by the community could become a caliph, whether or not he descended from Quraysh, the Prophet's tribe. This was unacceptable to the Shīʿa. They vested the right of caliphate and indeed, the right to interpret the Law, in the *Imām*, the rightful heir of the Prophet, who must, by definition, be from his progeny. The Imāmite contended that in addition to the birthright to authority, it was indispensable for the Imām to have received a personal investiture, designating him as endowed with a supernatural privilege: *ʿiṣma*, impeccability, an arbitrary infallibility, guaranteeing him immunity in relation to God and freedom from accountability before men.

Between these extremes, the majority of Muslims followed the middle way. They were called *Ahl al-Sunna waʾl-Jamāʿ*, the people of the Way of the

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13. The name is derived from *shīʿat ʿAlī*, the partisans of ʿAlī.
14. The term literally means "the upholders of *irjāʿ*" and is derived from the Qurʾānic usage of the verb *arjā* (in non-Qurʾānic usage *arjāʿ*), meaning "to defer judgment", *cf.* Q. 9:106. *Murjiʿa* identified faith (*imān*) with belief, or confession of belief to the exclusion of acts. See "Murjiʿa", *EI*, vol. vii, pp. 605-7.

Prophet (*sunnites*). They maintained that since all actual power comes from God, one must obey any non-apostate Muslim leader, go to prayers and to war under his order without probing too much about his virtues and vices, provided he publicly honors, respects and practices the basic tenets of Islam.

It was during these political and social upheavals that the first major theological controversies arose in Islam; these gave birth to various systematic schools of thought. One of the first such controversies hinged upon the nature of human freedom which had fundamental implications for the political situation of the time. Freedom meant responsibility; it meant that the caliph could not absolve himself from his deeds by invoking an inexorable decree of God. Predestination, on the other hand, meant the opposite. This is how a third group of scholars, the *mutakallimūn*, arose in Islam. They are sometimes regarded as being competitors to the other two groups of scholars, the jurists (*fuqahāʾ*) and the traditionalists (*muḥaddithūn*), but their area of interest was well-defined and different from the others. Initially, the mutakallimūn were mainly interested in the questions related to free will and predestination, nature of divine justice, hell and heaven and divine attributes. They also formulated a physical theory which was to have important implications for the Islamic scientific tradition; it is briefly discussed in a subsequent section of this chapter.

The Beginning of the Islamic Scientific Tradition

Our knowledge about the origin of the Islamic scientific tradition is still very fragmentary. Most of the primary texts have been either lost or remain unstudied. This is especially true for the period before Jābir ibn Ḥayyān who is said to have died in 160/777. What is certain, however, is the presence of early medical and astronomical traditions that go back to the days of the Prophet. Soon after his migration to Madinah, the Prophet had established a school in his mosque where ʿAbd Allāh b. Saʿīd b. al-ʿĀṣ taught the art of writing.[15] We also know that one form of ransom for the Makkan prisoners of war in the battle of Badr (2/624) was teaching of children for a fixed duration. There are also reports about the existence of

15. On these early developments, see Azmi, Mohammad Mustafa (1978), *Studies in Early Hadith Literature*, American Trust Publications, Indianpolis, pp. 1-5, wherein he quotes some of the earliest sources in support of his claim that the educational policy of the Prophet had established schools in Madinah where reading and writing was taught.

public libraries as early as the middle of the first century of Hijra.[16]

At any rate, the Umayyad prince Khālid b. Yazīd b. Muʿāwiya, the Ḥakīm (philosopher) of the family of Marwān, who flourished in Egypt (d. 85/704 or 90/708) did have a library and is said to have encouraged the first translations from Greek into Arabic. He was interested in medicine, astrology and alchemy. He also made the first contacts with the Alexandrian scholars. But we do not know much about his own works, though legend ascribes a large number of alchemical works to him. We also have a critical edition of the small book that appeared in Paris in 1559 with a rather dramatic title, *Booklet of Morienus Romanus, of the Old Hermit of Jerusalem, on the Transfiguration of the Metals and the Whole of the Ancient Philosophers' Occult Arts, Never Before Published*. This small volume, which set afloat the Latin Morienus, is considered to be the first alchemical work to have reached the West.[17] This text undoubtedly establishes Khālid's diligent search for the genuine practitioner of the art of alchemy as well as his interest in translations of ancient scientific texts into Arabic. Of course, flourish and legend have been added to the Latin text, but the "entire Latin tradition of the Morienus appears to derive from a single source, which was certainly a translation from Arabic."[18] No Arabic original is known but a number of identical passages can be found in various Arabic works, including the thirteenth century work of Abūʾl Qāsim Muḥammad ibn Aḥmad al-Irāqī, *Book of Knowledge Acquired Concerning the Cultivation of Gold*.[19] Al-Irāqī also quotes a number of alchemical verses of Khālid. Ibn al-Nadīm tells us in his *Fihrist* that he had himself seen four books by Khalid: *Kitāb al-Hararat, Kitāb al-Ṣahīfatul Kabīr; Kitāb al-Ṣahīfatul Ṣaghīr* and *Kitāb Waṣīyya ilʾl Ibnuhu fīʾl Ṣanʿa*.[20]

The sixth Shīʿī Imām, Jaʿfar al-Ṣādiq (80-147/700-765), who is said to be

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16. For example, the library of ʿAbd al-Ḥakam b. ʿAmr al-Jumāḥī contained *kurrāṣāt* (books) for public use, Azmi (1978), p. 5.
17. The Latin text was entitled *Morieni Romani, Quondam Eremitae Hierosolymitani, de transfiguratione metallorum, & occulta, summaque antiquorum Philosophorum medicina, Libellus, nusquam hactenus in lucem editus. Paris, apud Gulielmum Guillard, in via Iacobaea, sub diuae Barbarae signo*, 1559. An English edition was published in 1974 as *A Testament of Alchemy*, edited and translated by Lee Stavenhagen (1974), The University Press of New England, Hanover, New Hampshire.
18. Stavenhagen (1974), p. 60.
19. *Kitab al-ʿilm al-maktasab fi ziraʿat adh-dhahab* (*Book of Knowledge Acquired Concerning the Cultivation of Gold*), edited and translated by E. J. Holmyard (1923), Paris.
20. *Fihrist*, p. 434.

the teacher and Master of Jābir ibn Hayyān, is also credited with some scientific works. His *Book of the Epistle of Jaʿfar al-Ṣādiq on the Science of the Art and the Noble Stone* has been published by Julius Ruska with a German translation.[21] Before proceeding further, let us place this emerging tradition in its social and historic context.

The Social Milieu

At the close of the first Islamic century (August 718), the Islamic tradition of learning had firmly established its roots in the newly emerged centers of learning, especially at Madinah, Kūfa and Baṣra. The social revolution that had accompanied the conquests had set in motion a vast chain reaction, political struggles had fractured the unity of the society and scholars; two civil wars had been fought, several new cities had been founded;[22] Islamic coinage had been minted and the Umayyads had passed the zenith of their rule.

While the earliest scientific works were being composed, a revolt against the Umayyads was taking shape in the newly conquered Iranian cities, especially in Merv. By Ramaḍān 129/747, this resurgent movement in favor of the ʿAbbāsids had gathered enough momentum for a westward march under the leadership of Abū Muslim; thus began the third civil war in Islam. By 132/749, ʿAbbāsid troops had taken control of Kūfa; on 13 Rabīʿ I, 132/750, Abūʾl ʿAbbās (posthumously called al-Saffāḥ) was proclaimed caliph at Kūfa; two months later, the Umayyads were decisively defeated at the battle of Greater Zāb and in June of the same year, most of them were massacred but ʿAbd al-Raḥmān I escaped to Spain where he established the Umayyad rule (138-423/755-1031).[23]

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21. *Kitāb Risāla Jaʿfar al-Ṣādiq fiʾl-ʿilm al-Ṣanʿa wal-Ḥajar al-Mukarram*, *Isis*, vol. 7, pp. 119-21.
22. These were initially garrison cities, later they became centers of learning and sciences. They include Kūfa, Baṣra, Fusṭāṭ (now Old Cairo) and Wāsiṭ.
23. ʿAbd al-Raḥmān b. Muʿāwiya b. Hishām (b. 113/731) had lost his father as a child. His mother was from the Berber tribe of Nafza. When the Umayyad state fell, he was living in the village of Ruṣāfa, on the banks of the Euphrates River. As the ʿAbbāsid soldiers surrounded his house, he and his younger brother took flight. They swam across the river; his brother was killed but he made it to the other side. After hiding in various places and traveling in disguise, he reached his mother's tribe and took refuge with his maternal uncles in the coastal city of Nakūr. From here he approached the Umayyad clients in al-Andalus. He entered Córdoba after defeating a local ruler 139/July 756 and was

These were uncertain times. The caliphate of Abū'l ʿAbbās was challenged, he had to fight wars with new contenders and the four years and eight months of his reign could hardly be described as a stable period. When he died in Dhū'l Hijjah, 136/753, his brother Abū Jaʿfar was in Makkah. He rushed back to Kūfa where his caliphate was proclaimed. But he also had to fight with other contenders of caliphate. In 145/762, Abū'l Jaʿfar decided to move his capital to a safer place. He himself went out to find a suitable place and chose Baghdad because of its pleasant climate and the two rivers, Euphrates and Tigris. The city was planned as a circular city with sixteen gates; it was called *Madinatul Islam*, the city of peace. A Persian astrologer and engineer, al-Naubakht (d. c.160/776-77) and Māshāllāh,[24] an Egyptian (?) Jew (d. *ca*. 199/815 or 204/820), made the measurements prior to the construction of the city. The construction was supervised by a Persian, Khālid ibn Barmak.

With the construction of Baghdad, we arrive at the dawn of the Islamic scientific tradition. From this point onwards, it becomes progressively easier to reconstruct the contours of the tradition. Our sources become increasingly more reliable and there is an exponential increase in the available texts. The accounts of the construction of the city tell us about the presence of a large number of specialists in various fields—engineers, astrologers, astronomers, medicine men—Muslims as well as non-Muslims, Arabs as well as non-Arabs, who took part in numerous projects. This establishes the fact that by then, there was already a flourishing tradition of interaction between scholars and scientists belonging to different religions and races. In time, Baghdad would provide a perfect meeting place for an enormously wide range of scientists and scholars; it would also become one of the main centers of a translation movement of unprecedented scope and proportions. We will discuss the relationship between this translation movement and the Islamic scientific tradition in the next chapter.

The fifty year period between 134/750 and 184/800 saw the rule of five

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proclaimed the *amīr* (ruler). He contented himself with this title, rather than claiming the Caliphate. Nevertheless, he ruled independently and the ʿAbbāsid caliphs let him be. It was not until 316/929, that the Umayyads in al-Andalus proclaimed their caliphate, and that too, only after a Shīʿite caliphate had been established in North Africa. For al-Andalus, see the excellent two volume work, Jayyusi, Salma Khadra (ed., 1994), *The Legacy of Muslim Spain,* 2 vols. E. J. Brill, Leiden.

24. His real name was probably Manasseh (Mīshā in Arabic), most Latin translators named him Messahala with variants such as Macellama and Macelarama.

ʿAbbasīd caliphs.[25] It was during this period that the second legal school (*madhhab*) emerged in Islam. This was based on the works of a number of scholars but was crystallized by the work of Mālik ibn Anas, the compiler of *Kitāb al-Muwaṭṭāʾ*,[26] one of the earliest collections of the Prophetic traditions. The first, or at least one of the earliest legal treatises on taxation, *Kitāb al-Kharāj*, was also written during this period by the able student of Abū Ḥanīfa (d. 151/768), Qāḍī Abū Yūsuf (113-183/731-799),[27] the first supreme judge (*Qāḍī ʾl-Quḍāʾ*) in Islam. All of these developments had deep social, political and religious causes. The Arabic grammar was also systematized during this period. This was to provide a fundamental structure for the emergence of precise definitions of technical terms that were used by the scientific tradition. One of the first books of Arabic grammar, simply called *al-Kitāb* (*The Book*), was written by Abū Bishr (or Abūʾl Ḥasan) ʿAmr ibn ʿUthmān ibn Qanbar (d. *ca*. 179/795),[28] a Persian student of al-Khalīl ibn Aḥmad (d. *ca*. 175/791), the founder of the science of Arabic metrics. The first astrolabes were constructed in the Muslim world.[29] The first members of the illustrious Nestorian family of physicians, the Bakhtyashū, arrived in Baghdad and the first translations of Persian medical works were made into Arabic.

This background makes it easier to see, at the outset of this tradition, that it was intimately linked to the religious, cultural, political and social

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25. Abūʾl ʿAbbās al-Saffāḥ (750-754); Abū Jaʿfar al-Manṣūr (754-775); al-Mahdī (775-785); al-Hādī (785-786) and Hārūn al-Rashīd (786-809).
26. *Lit*. *The Book of the Beaten Road* or *The Book of the Smooth Path*, containing about 1700 juridical traditions arranged according to the subject, with remarks on the *Ijmāʿ* of Madinah. 15 recensions are known; two have survived in their entirety; numerous contemporary editions exist along with many commentaries, *cf. GAL* vol. 1, p. 176 and 297-9; also *GAS*, vol. 1, pp. 457-84.
27. Arabic edition (Būlāq, 1302/1884), French translation with notes by Fagnan: *Le Livre de l'imôt foncier*, Paris, 1921, also see *Isis*, vol. 4, p. 579; *GAL* vol. 1, p. 171.
28. *GAL*, vol. I, p. 101; also, Derenbourg, Hartwig (1881-89), *Le livre de Sibawaihi*, 2 vols, Paris, German translation based on Derenbourg's text, with extracts from the commentaries of Sīrāfī (d. 368/978-9) and others by Jahn, G. (1894-1900), 2 vols. in 3, Berlin; cited from Sarton, George (1931-48), *Introduction to the History of Science*, 3 vols. The Williams & Wilking Company, Baltimore, vol. 1, part 1, p. 542.
29. One of the first to do so was Abū Isḥāq Ibrāhīm ibn Ḥabīb ibn Sulaimān ibn Samura ibn Jundab (d. *ca*. 161/777); he also wrote some of the earliest works on astrolabe, on the armillary spheres and on the calendar; he is also credited with a *qaṣīda* in praise of astrology.

fabric of the society. The intellectual tradition that emerged from this milieu was more Persian than Arab in many aspects, though its language of expression was Arabic. The message of Islam had made a profound impact on the Persians. Their love of the Prophet and his family, their lofty artistic aspirations, their sense of justice and their urbanity—all played a decisive role in their contribution to the tradition. The ʿAbbāsids had moved westward from Persia, their staunch allies were mostly new Persian Muslims who accepted their claim to authority because of their kinship to the Prophet. Thus, it is not surprising that the first generation of Muslim scientists and scholars who were patronized by the ʿAbbāsids were mostly non-Arabs and some of the most important thinkers of Islam would come from Persia: Ibn Sīnā (370-428/980-1037), Abū Bakr Muḥammad b. Zakariyyā al-Rāzī (*ca.* 250-313/854-925) and Abū Ḥāmid Muḥammad b. Muḥammad al-Ṭūsī al-Ghazālī (450-505/1058-1111).

The Arab contact with Iran was not a mere accident. Mention has already been made of the impact of Islam on the Persians. But the impact was not just unidirectional. The Persianization of the emerging Islamic intellectual tradition is equally important. It was through Iran that the Arabs would find access to some of the most important sources of ancient texts. Iran had remained open to diverse influences for centuries. These include the Greek, Christian, Indian, Zoroastrian and Mānī influences. Located almost half-way between the Arab hinterland and the vast central Asian steppes of various Turkish tribes, it not only provided the necessary link for Islam's inevitable arrival beyond the river Oxus, it also became a conduit for the intellectual links with the Greeks, Byzantines and the Indians.

The paucity of resources does not allow us to reconstruct the early history of the Islamic scientific tradition but this social and political background does explain—at least to some extent—the "sudden" appearance of an intellectual activity that was already mature at birth. Note that by the middle of the second century of Islam, the core Islamic sciences had been firmly established and it had matured to encounter foreign currents and ideas. But what is more important for our purpose is the fact that some of the most important questions to be addressed by the Islamic scientific tradition in those early decades had already surfaced in the context of religious sciences.

Reflecting on the nature of relationship between God and the created beings, a number of mutakallimūn, mystics and thinkers had formulated theories about the nature of the universe, the human body, soul and their mutual relationship. For example, the already mentioned crucial question of free will raised by the Khārijites in legal terms had such grave consequences that it could not be taken lightly by any school of thought: If humans are free in their actions, would a person who committed one of the grave sins (*kabāʾir*) still be a Muslim? The Khārijites had answered it with a firm negative, the Murjīʾites had remained non-committal, al-Ḥasan al-Baṣrī had withheld judgment but his student, Wāṣil b. ʿAṭāʾ (d. 131/748), disagreed with his master and asserted that a grave sinner must be placed in an intermediary position (*manzila bayna manzilatayn*) between infidelity (*kufr*) and faith (*īmān*). After making his statement, he withdrew from the circle to another pillar in the mosque and was followed by ʿAmr ibn ʿUbayd and others. Al-Ḥasan then remarked, "Wāṣil has withdrawn (*iʿtazala*) from us,"[30] This was the beginning of a new school of thought in Islam—the Muʿtazila. Wāṣil's contemporary Jahm b. Ṣafwān (d. 128/746), the founder of the Jahmite school, believed in an uncompromising divine omnipotence and, consequently, absolute determination of all human actions by God. Those who shared this view were called the Jabrites (Determinists). In addition to this crucial question, the other problems that arose in these early years included the following: Was the Qūrʾān created in time or was it eternal? Was God's essence identical with His attributes? What was the nature of hell and heaven?

Both the Jabarites and the Muʿtazila believed in the creation of the Qurʾān, they also shared the belief that God's attributes were identical with His essence, but whereas Jahm believed in the ultimate destruction of heaven and hell, together with their inhabitants, the Muʿtazila believed in the eternity of punishment and reward and hence that of hell and heaven. These questions took center stage because of their legal, social and political importance. The earliest scholars to discuss these issues included Maʿbad al-Juhanī (d. 80/699), al-Ḥasan al-Baṣrī (d. 110/728), Ghaylān al-Dimashqī (d. before 126/743), Wāṣil b. ʿAṭāʾ (d. 132/748) and ʿAmr b. ʿUbayd (d. 145/762). In time, the Kalām tradition solidified into two major schools: the Muʿtazila and the Ashʿaria.

The mutakallimūn were also interested in cosmological doctrines and,

30. This standard account, quoted by many scholars including Watt, Montgomery W. (1973), *The Formative Period of Islamic Thought*, Edinburgh University, Edinburgh, pp. 209-17, is not without problems; also see van Ess "Muʿtazilah" in Eliade, M. (ed., 1987), *Encyclopedia of Religion*, Macmillan, New York and London, vol. x, pp. 220-1.

more importantly, in formulating a comprehensive physical theory that deals with many aspects of space, void and matter. This physical theory evolved from the works of the first generation of mutakallimūn; by the third/ninth century, it had achieved a remarkable degree of sophistication and it blossomed in the works of the fourth-fifth/tenth-eleventh century mutakallimūn.

Kalām Physical Theory

What are the ultimate constituents (*dhawāt*) which make up the world? What are their attributes and properties? Are these "properties" separate from the "things" they define or are they inseparable from the "things"? These were some of the major questions addressed by the Kalām physical theory.[31] Three basic postulates of the Kalām Physical Theory are: (i) "things" are only constituted out of accidents; (ii) "things" are constituted out of interpenetrating corporeal bodies, and (iii) "things" are constituted out of atoms and inherent accidents. According to the first doctrine, held by Ḥafṣ al-Fard (*fl*. *ca*. 195/810), Ḍirār ibn ʿAmr (d. 200/815), and al-Ḥusayn al-Najjār (d. *ca*. 220-230/835-845), the world consisted of only accidents (*aʿrāḍ*, sing. *ʿarḍ*) and therefore all attributes and properties of the objects of the world are defined by these accidents. Those who held the second doctrine, such as Ḥishām ibn al-Ḥakam (d. 179/795), al-Aṣamm (d. *ca*. 200/815), Ibrāhīm ibn Sayyār al-Naẓẓām (d. *ca*. 220-230/835-845) and his followers, believed that the created world consisted of bodies. The last doctrine, which became the dominant Kalām position in the later periods, held that the created world consisted of corporeal atoms and incorporeal accidents which inhere in atoms. This doctrine defined the properties of objects as an aggregate arising from the intrinsic nature of the atoms that constitute them, the accidents which inhere in them, and from the combination of these atoms with their inherent accidents to form larger units. This atomistic doctrine was a totally independent development in the Islamic intellectual thought, without any links to the Greek Atomism for there is no mention of any Greek texts having been translated at this early

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31. For an outline and detailed discussion of Kalām physical theory, see Dhanani, Alnoor (1994), *The Physical Theory of Kalām*, E. J. Brill, Leiden, pp. 6-7 and *passim*. Also see Dhanani, Alnoor, "Kalām atoms and Epicurean Minimal Parts" in Ragep, Jamil F. and Ragep, Sally P. (eds., 1996) *Tradition, Transmission, Transformation,* E. J. Brill, Leiden, pp. 157-71.

stage.[32]

These questions were invariably bound with the epistemological considerations: how do we know what we know? This was recognized by all and thus, epistemological considerations formed an integral part of the Kalām physical theories. The dominant view, held by most Muʿtazilīs, was that the "ultimate constituents of the world are real and concrete (and not ideal and theoretical) entities…[and that] it is possible for us to have true knowledge of these constituent entities and their properties."[33] This was a realist epistemology which pitted the mutakallimūn against the skeptics who believed that knowledge of objects, as they are in themselves, is impossible.

In their technical lexicon, the mutakallimūn referred to atom as *jawhar* and distinguished this term from its usage by the falāsifa, who used it to denote the peripatetic view of substance. In their definition, atom (*jawhar*) was explicitly defined as "that which occupies space" (*mutaḥayyiz*). Thus in the very conception of the most fundamental constituent of matter, atom, the mutakallimūn had a built-in notion of space; it was impossible to conceive the atom without, at the same time, conceiving space because, atom, by definition, was a space-occupying thing. A related question was whether the intervening space between the two atoms was empty or not. In other words, could void exist? Or, to put it in yet another way, was the universe a plenum or not? Thus a discussion of atom simultaneously involved the discussion of space and void. Mutakalimūn defined void as being of two kinds: the intercosmic void (spaces between the particles which constitute the cosmos), and the extracosmic void which exists beyond the bounds of the finite universe. Note that for the Greek Atomists, the question of the extracosmic void did not arise because their universe was infinite, containing infinite cosmoi.

The falāsifa also addressed this question. Yaʿqūb ibn Isḥāq al-Kindī (d. 256/870) defined void as a place without any spatial object in it, whereas Muḥammad ibn Zakariyyā al-Rāzī (d. 313/925), one of the most important

32. Dhanani notes that "the question of the origins of *Kalām* atomism and its links with Greek Atomism has been the primary focus of most twentieth century research into *Kalām* physical theory. This narrow focus has limited the examination of *Kalām* atomism to the early period of the development of *Kalām*. Such a research program is beset by several methodological difficulties, the most challenging of which is the paucity of sympathetic accounts of early *Kalām* atomism." Dhanani (1994), p. 6; also note 13.

33. Dhanani (1994), p. 21.

Muslim scientists and philosophers, held the radical concept of absolute space in which material objects are embedded. In his metaphysics, this absolute space or void was one of five eternals, the others being God, soul, matter, and absolute time.[34]

Although a discussion of al-Rāzī's views is premature at this stage, it is important to point out that he stands somewhat alone in his commanding position as a scientist and a philosopher. His fierce independence, his brisk, almost arrogant, rejection of all those whose views he contested, his careful reconstruction of fundamental concepts, and his reliance on meticulous experimental details—all contribute toward making him a towering figure in the history of Islamic tradition. In his view,

> the reality of existence of an infinite three-dimensional space independent of bodies is proven by the fact that men whose judgment has not been corrupted by scholarly quibbles are certain of its existence. The same applies to the concept of time, considering as a flowing substance existing independently of motion. Thus, in a way which *mutatis mutandis* may remind us of Descartes' method of philosophizing, the certitude which attached in the human mind to these concepts was a proof of their external reality.[35]

Another important distinction made by Rāzī between absolute and relative space led him to postulate that the former was not subject to measurements whereas the latter was measured by means of the number of revolutions of the heavenly spheres. Thus, in Rāzī's view, the cosmos was not a primary datum, absolute space and time were more fundamental than the cosmos. Likewise, he held that matter had an atomic structure and subsisted before bodies were formed in a state of dispersion. "The cosmos characterized by the order prevailing in it was thus something derivative and not self-sufficient.... It was created and would in the fullness of time be dissolved."[36] In order to account for the divine, al-Rāzī would, perhaps late in his life, postulate his famous five eternals (God, soul, matter, absolute space and time), in whose existence the universe was a mere interlude.

We will discuss al-Rāzī in due time; however, for now, let us return to the

34. Dhanani (1994), pp. 71-72.
35. Pines, Shlomo (1986), "What was original in Arabic science" in *Studies in Arabic Versions of Greek Texts and in Medieval Science,* The Magnes Press, The Hebrew University, Jerusalem, p. 193.
36. Ibid.

story of the Islamic scientific tradition. While the mutakallimūn were busy in their discussions, there arose a small body of literature, rather quietly, in an entirely different realm—this was the first flowering of the Islamic scientific tradition.

The First Flowering

The first few decades of the Islamic scientific tradition are still shrouded in the dim pre-dawn light. The paucity of information makes it rather difficult to draw a clear picture with confidence. The sudden appearance of a small group of scientists and scholars who are dealing with rather advanced theories does not let us traverse the earlier terrain; it brings us right into the full exposure of the scientific activity in the second half of the second/eighth century. This small group includes Persians, Jews, Muslims, Christians and Nestorians who speak and understand Syriac, Sanskrit, Hebrew and Greek, though they write mostly in Arabic. The meeting place is Baghdad. Their subject areas are mathematics, astronomy, alchemy, natural history and medicine. They already know something about the Greek, Persian and the Indian scientific traditions; they comment on this body of knowledge, they adopt it according to their needs, they reject part of it, they produce critique of this literature, they coin new terms in Arabic to grasp the ideas contained in non-Arabic works. But what is most important for our study is the fact that rather than being mere scientists dealing with experimental data and procedures, they are also theoreticians.

Equally important are the questions they ask, themes that attract them and theories they propose. But it is precisely this that defies classification, for all of them were much more than astronomers, chemists and mathematicians; they were immersed in an all-embracing tradition of learning. Most of them wrote on a wide range of subjects—from anatomy to the intricacies of Arabic grammar and from the construction of astrolabes to the poetry of the pre-Islamic poets.

Let us also note that the Islamic scientific tradition preceded the translation movement that would bring the Greek, Persian and Indian scientific texts into this emerging tradition. Even our meager resources amply prove this. Astronomy, medicine and mathematics were already established fields of study before any major translations were made into Arabic. Translations were done to enrich the tradition, not to give birth to it, as some Orientalists have claimed. In the field of astronomy, for example, George Saliba has conclusively shown that the first generation of astronomers which included Yaʿqūb b. Ṭāriq[37] and others were working "before the time of the great translation movement which produced Arabic versions of such Greek scientific masterpieces as the *Almagest* and the *Elements*."[38] He also shows how this early astronomical tradition was related to the Qurʾānic cosmology. The pre-Islamic astronomy which predicted and explained seasonal changes based on the rising and setting of fixed stars (known as *anwāʾ*) was a subject of interest for the Qurʾānic exegetes as well as for the early lexicographers who produced an extensive literature on the *anwāʾ* and *manāzil* (lunar mansions) concepts.

> The cosmological tradition of the Quranic text would later produce a separate type of astronomical literature usually referred to as *al-hayʾa al-sunnyīa*. The use of the term *hayʾa* to describe this tradition as well is of special significance, for it indicates the direction from which this tradition had developed. It is not a coincidence that the mathematical astronomical tradition which dealt with the theoretical foundations of astronomy also defined itself as a *hayʾa* tradition, even though it rarely touched upon the Quranic references to the cosmological doctrines.[39]

The towering figure among this early group of scientists is, of course, that of Jābir ibn Ḥayyān. But the fact that the Jābirian corpus contains a large number of highly sophisticated works of an enormously wide scope, indicates that there must have been a flourishing scientific tradition much before Jābir's time because such mature works could not have come into existence within the life time of one person. Dating of Jābir's vast corpus and even its authorship has remained controversial for centuries. In recent times, Paul Kraus has added the weight of his considerable authority to this

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37. The author of *Maḥlūl fiʾl-Sindhind li Daraja Daraja* (*Astronomical Tables in the Sindhind Resolved for Every Degree*), *Tarkīb al-Aflāk* (*Composition of the Spheres*), and *Kitāb al-ʿillal* (*The Book of Causes*), *fl*. Baghdad in the second half of the 8th century; he is most closely associated with al-Fazārī; see Pingree, David "Yaʿqūb ibn Ṭāriq" in DSB, vol. 14, p. 546; "Fragments of the Works of Yaʿqūb ibn Ṭāriq" in *Journal of Near Eastern Studies*, vol. 27, pp. 97-125; and Kennedy, E. S. (1967), "The Lunar Visibility Theory of Yaʿqūb ibn Ṭāriq" in *Journal of Near Eastern Studies*, vol. 27, pp. 126-32.
38. Saliba, George (1994), *A History of Arabic Astronomy*, New York University Press, New York and London, p. 16.
39. Saliba (1994), p. 17.

controversy; he attributed the *Corpus Jābirianum* to a group of authors of the tenth century. His work, which assembled a large collection of manuscripts, was important for several reasons: it placed these texts in a comprehensive historical setting, it classified them and gave them a manageable format. But Kraus did not have all the texts or historical material at his disposal and he died before he could finish his work on Jābir. Following Kraus rather uncritically, most of the modern scholars continued the same line of thought. They refined the parameters, edited more texts and studied more carefully those that had been edited by Kraus, but they did not question the basic framework of inquiry and its most fundamental premise: the dating and the authorship of the corpus. This dogmatic acceptance of dating and authorship led many historians of science to make false comparisons between Jābarian corpus and later works such as the *Rasāʾil* (*Epistles*) of the Ikhwān al-Ṣafāʾ (Brethren of Purity, *ca*. 373/983); this is also the main cause of many other historically incorrect theories which have been formulated on the ideas first postulated by Kraus.[40]

This situation changed in 1994 with the publication of *Names, Natures and Things* by Syed Nomanul Haq.[41] This book is a veritable storehouse of ideas, painstakingly researched information, hundreds of cross-referenced citations, and a coherent synthesis of various strands that run through Jābirian corpus. It has conclusively shown that there was, in fact, a man by the name of Jābir, the son of Ḥayyān, who had a personal relationship with the sixth Shīʿī Imām, Jaʿfar al-Ṣādiq. Jābir's patronymic name (*kunya*) is variously given as Abū Mūsa and Abū ʿAbd Allāh, with the epithet al-Ṣūfī, his tribal name (*nisba*) is given as al-Azdī and he was either from Kūfa or Ṭūs; hence called al-Kūfī or al-Ṭūsī. Ibn Khallikān calls him Jābir ibn Ḥayyān of Tarsūs[42] meaning that he was from Tarsūs. Ibn al-Nadīm says, "...the Shīʿa have said that he was one of their great men and one of their *abwāb* (doors). They claim that he was a companion of Jaʿfar al-Ṣādiq (may

40. For later studies, see, for example, the facsimile of the Arabic text of the *Poison Book* (Kraus no. 2145), published in 1958 by A. Siggel with a German translation and the 1950 French translation of *Livre du glorieux* (Kraus no. 706) by Henry Corbin. For erroneous synthesis, see the review on Marquet, Y. (1998), *La Philosophie des alchimistes et l'alchimie des philosophes: Jābir ibn Ḥayyān et les "Frères de la Pureté"*, Paris by Haq, S.N. (1992), *Isis*, vol. 83, pp. 120.
41. Haq, Syed Nomanul (1994), *Names, Natures and Things*, Kluwer Academic Publishers, Dordrecht, Boston, London. I have drawn heavily on this work for the construction of my arguments in this section.
42. *Wafayāt,* vol. 1, p. 327.

Allah be pleased with him)....The man is authentic, his case is most apparent and well known, his compositions are important and numerous…it is said that his origins was Khurāsān."[43]

Jābir's enormous corpus contains "theory and practice of chemical processes and procedures, classification of substances, medicine, pharmacology, astrology, theurgy, magic, the doctrine of specific property of things (*ʿilm al-Khawāṣṣ*), and the artificial generation of living beings,"[44] as well as discourses on the occultation of the Imām. In its sweeping breadth, the corpus contains references to diverse sources, ranging from Hermes to Aristotle and Balīnās (Apollonius of Tyana). An important aspect related to the proper dating of Jābirian corpus is the comparison made by Haq between Jābir's quotations from Greek works with those of third/ninth century Arabic translations. Haq has shown that though Jābir refers to his Greek predecessors throughout his corpus, in a vast majority of instances he either paraphrases their writings, or simply explains their doctrines in his own words; this indicates that he lived before the formal translation movement began. But it is on the basis of direct translations found in Jābir's *Aḥjār* that Haq has established his irrefutable evidence. These direct quotations are translated in an archaic style and the terminology is not as refined and consistent as the one found in the mature translations of Isḥāq ibn Ḥunayn.[45]

In any case, our main concern here is with the doctrinal part of Jābir's corpus and especially with his "Science of Balance". Jābir's theory of qualities is at the heart of his whole scientific system. In an attempt to explain the natural world, he constructs a grand system based on four qualities [hot, cold, moist and dry] which are not the four Empedoclean elements which his Greek predecessors had hypostasized; rather Jābir accords this position to the qualities. And this means that qualities, and not the Empedoclean primary bodies, were the true elements of his system. Thus, as far as Jābir is concerned, in the intelligible world existed not some "absolute Fire," but the "incorporeal hot." Jābir does not even designate his four qualities with Aristotelian appellations, *dunamis (quwā,* sing. *Quwwa)* or *poiotês (kayfiyyāt,* sing. *kayfiyya);* rather, he variously calls them 'principles' (*uṣūl,* sing. *aṣl)*, 'bases' (*arkān,* sing. *rukn),* 'first simples,' 'first elements and, often, 'natures' (*ṭabāʾiʿ,* sing. *ṭabʿ).* At times, he explicitly distinguishes them

43. *Fihrist*, p. 435.
44. Haq (1994), p. 5.
45. Haq (1994), pp. 25-30.

from *kayfiyyāt*. "The appellation 'nature' was never used by Aristotle in this sense," Haq notes, "here we have, then, a case of a profound conceptual and terminological difference.[46]

Through this independence and corporeality, Jābir's four qualities become true elements, which are, in the natural world, corporeal, subject to a wide range of quantitative manipulations. The intensities of qualities in a body are, therefore, measurable and Jābir proposes an extended scheme of elaborate subdivisions, using units borrowed from ancient astronomy, thus attempting to "elevate the practice of medicine to the infallibility of an exact science"[47] All of this leads one to the question of intensities of qualities and to Jābir's most important contribution: the Science of Balance (*ʿilm al-Mizān)* which he thought was "a divine science (*ʿilm lāhūtī)* whose aim was to reduce all facts of human knowledge to a system of quantity and measure. However, the scope of this science was not limited merely to the measurement of qualitative potencies of drugs—in fact, 'all things fall under the [principle of] Balance,' and 'it is by means of this principle that man is able to make sense of the world'."[48] It is this "Theory of Balance" that is the foundation upon which Jābir constructs his whole system which is characteristically Islamic; it recalls, celebrates and builds upon the central concept of Islam, the Unicity of God, *al-Tawḥīd*, in such a seamless way that there remains no need for any artificial imposition of the Qurʾānic doctrine of a well-balanced and well-proportioned creation on Jābirian system; the system is borne out of this central Qurʾānic notion. Jābir's doctrine encompasses both the sub-lunar world of generation and corruption as well as that which is beyond the Sphere (*al-Falak*). As a methodological thesis,

> Jābir's Balance was the 'way' (*ṭarīq*) through which one understood, made sense of, and, above all, measured and manipulated the objects and the processes of the universe. And since the universe was diverse, so were the Balances. Thus there are Balances of the Intelligence, of the Soul, of Nature, Form and the Sphere of the stars; there are Balances of the four natures, animals, plants and minerals—these are all useful Balances. But, finally, there is the Balance of Letters: and this is the most perfect of all.[49]

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46. Haq (1994), pp. 59-60.
47. Haq (1994), p. 67.
48. Ibid.
49. Haq (1994), p. 81.

This best of all Balances—variably called the Balance of Letters (*Mizān al-Ḥurūf*), the Balance of Articulation (*Mizān al-Hijjā*ʾ) and the Balance of Utterance (*Mizān al-Lafẓī*)—is elucidated, defended and justified in a systematic way. This enables Jābir to build a comprehensive theory of knowledge, language and music. But Jābir is not merely interested in the formulation of a theory, he is attempting something far greater. He is attempting to construct a philosophical system on the basis of his central principle, *Mīzān al-Ḥurūf,* to systematically explain harmony and balance that exist in the world of nature.

After formulating his "Theory of Balance" in a coherent manner, Jābir then develops an ontological equivalence between the four natures and the Arabic alphabet. He submits all change to the exactness of mathematical laws and calls it the Supreme Principle (*Qāʿida ʿuẓmā*) of the world which governs everything—from the distances and movements of the celestial bodies to the specific, immutable and noble proportions of the four qualities that all bodies contain. He even goes to the extent of showing that this proportion was exactly 1:3:5:8 whose sum, 17, was the foundation (*Qāʿida*) of the entire "Science of Balance". By discovering this quantitative structure of all things, an alchemist can learn how to change one thing into another—even inanimate objects into living things—by reconfiguring the qualities. He devotes an entire collection of texts, called *Kutub al-Mawāzīn* (Books of Balances), to the development of these ideas. Recalling the Qurʾānic theme of balance and order in the created universe, affirmed with a particular force throughout the text of the Qurʾān, one begins to understand the foundational links between the Qurʾān and the scientific tradition that was emerging in the Islamic milieu at this early stage. The Qurʾān declares that everything has been created in due proportion and in pairs (Q. 22:5; 26:7; 25:2; 31:10; 50:7; 54:49) and the Creator has established balance (55:7). In Jābir, then, we have a scientist of the first rank, who is attempting to develop a whole system in which one can clearly discern the reverberations of the Qurʾānic doctrine of balance.

By the end of the second century of Islam (August 815 CE), the Islamic scientific tradition had taken firm roots in the newly established intellectual centers of the Muslim world. It had also found ample support and patronage. During the next six centuries, it was to witness an unprecedented expansion, both geographically as well as intellectually. But before tracing further developments, let us see how this tradition was rooted in the Qurʾān.