Situated Arabic Science

Locality versus Essence

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LOCALITY AS A FOCUS OF HISTORIOGRAPHY

I trust that no one would wish to contest the proposition that all history is local history—whether the locality is that of a short episode or of a long story. All history is local, and the history of science is no exception. There can be no history of science that is not concerned with a localized episode or a sequence of such episodes. Philosophers of science, or some of them, may restrict themselves to analyzing the formal or logical and timeless structure of a piece of scientific thought; or they may substitute an emphasis on growth as a basic feature of scientific inquiry that requires for its logical elucidation the addition of a temporal dimension that retains an abstract character. But historians of science have a different task. For while they can ignore the cognitive core of scientific practice only at the cost of forfeiting their claim to a distinctive problematic and a distinctive discipline, they are especially concerned with science as a process that takes place in actual time or science as a series of phenomena that, owing to their special character of chronological and geographical locality, we call "historical"—this "special character" being due to the fact that the phenomena in question are not merely in space and time but events associated with, and indeed produced by, individuals acting in what we broadly call "cultural settings." The thesis outlined in these few abstract sentences is but a generalization of a weak version of the familiar contextualist thesis in scientific historiography; or, to put it another

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way, contextualism is but an obvious consequence of the simple, undeniable fact of the local character of all events, including historical events. Since a historical event is where and when and how it is, inseparably tied to all the circumstances that combine to define it for us as historians, then, to be genuinely historical, all history of science must be contextual, because all historical events are local.

I said “weak version” because I do not wish to subscribe to a stronger, reductionist version that seems to me to misinterpret the local character of cognitive expression and behavior by appearing to deprive them of objective import. At the risk of being much too brief, let me indicate what I mean with just a sentence or two before I get on to my subject proper. I am persuaded, as I hope you are, that locality is not a property of a piece of scientific thought—say, the Pythagorean theorem. In other words, the Pythagorean theorem, not being an event in the spatiotemporal world, has no space-time coordinates. But recognizing it as a theorem in a given geometrical system with certain definable features was the achievement of someone or other who certainly had such coordinates. From this it would seem to follow that the historical study of scientific thought is, strictly speaking, not concerned with the thought content of science as such (that would be to engage in science, logic, or philosophical analysis), but with the historical occurrence of the recognition of thought. I am aware that all of this has been said before and in various ways by philosophers and historians to serve rather different agendas. So, to avoid misunderstanding, I will just add the observation that recognition of thought always involves, among other things, a cognitive context that itself is location-bound, in the sense of being part of a problem situation that depends on the existing state of knowledge at a given time and place. And this means that engaging in science, logic, and philosophical analysis may all be involved in the historical study of scientific thought.¹

My purpose here is to try to illustrate the advantages of a strict adherence to the axiom of locality in situating the tradition of Arabic science with reference both to the place that this tradition occupies in the general history of science and to its place in the civilization where it emerged and developed. My discussion will thus be concerned with two contexts that, though distinct from one another, are, as I shall suggest, intimately connected with each other. Obviously what I shall present to you can only be the bare sketch of what might be described as a framework for research, but, I hope, a framework that is not irrelevant to other scientific traditions and that may even propose a correction to other historiographies that seem to pay little or no attention to the intercultural transmission of scientific knowledge.

Let us begin with an apparently neutral and innocent definition of Arabic, or what may also be called Islamic, science in terms of location in space and time: the term Arabic (or Islamic) science denotes the scientific activities of individuals who lived in a region that roughly extended chronologically from the eighth century A.D. to the beginning of the modern era, and geographically from the Iberian Peninsula and North Africa to the Indus valley and from southern Arabia to the Caspian Sea—that is, the region covered for most of that period by what we call Islamic civilization, and in which the results of the activities referred to were for the most part expressed in the Arabic language. We need not be concerned over the refinements that obviously need to be introduced even into this seemingly neutral definition. But what about the term scientific in it? What does it mean, and

¹ For ideas underlying the theoretical structure of this essay I am indebted to the writings of Gottlob Frege (on the distinction between thought and recognition of thought), Karl Popper (on methodological individualism, situational logic, interaction of Worlds 1, 2, and 3), and Alfred North Whitehead (all about events).
can it be regarded as in any way "innocent"? To me it seems clear that the only correct answer to this last question must be an unequivocal No. Science and scientific are our own terms and they express our own concepts (which, by the way, does not mean that they are sharply defined or unproblematic); and, therefore, the study of any past intellectual activity can be relevant to what we call "history of science" only to the extent that such an activity can be shown to help us understand the modes of thought and expression and behavior that we have come to associate with the word science. This is not anachronism, presentism, whiggism, or any of the other objectionable isms, but a consequence of the fact that we who are writing the history also have a location of our own that defines our perspective and, hence, the questions we pose from our vantage point and the terms in which these questions are framed. Nor should this admission to a definite point of view discourage or detract from investigating past modes of thought and expression and behavior under other categories deemed suitable for elucidating these modes "in their own terms," as the phrase goes. But, without aiming to replace other approaches that put the emphasis on certain concerns of sociology or anthropology or cultural history, our historiography of science will always change as a function of our changing position, being ourselves forever located at the end point of the process that is continually shaping and reshaping what we call "science." And so I am led to combine a self-evident proposition with another that seems no more, and no less, than a corollary of it: that all history of science is local, and no history of science can ever be neutral.

The character of Arabic science, its strengths and failings, the course of its development, and its ultimate fate have all been variously explained in terms of language as a matrix of thought and expression, of religion as an inexorable shaping force, of natural aptitudes or inclinations of a certain race or inherent mentality, or as one inevitable expression of a world culture of which Islamic civilization was a late embodiment. A perceived emphasis on algebra in the Arabic tradition has been attributed to certain features of Semitic languages that make these languages or their native users prone to "algebraization," as opposed to Greek "geometrization." The persistent attempts of Islamic astronomers to construct kinematic models primarily designed to save the principles and the logical consistency of Ptolemaic astronomy have been seen as a sign of poverty of imagination or of the tendency of the "Semitic mind" toward things it can easily perceive by the senses. Islamic religion has been cited both as the origin and source of vigor of medieval Islamic science and as the major cause of its final demise. And the "spirit of culture," in this case a Magian culture already at work in "so-called" late antiquity, has been invoked to account for every aspect of Islamic civilization, including its scientific products.²

It is not difficult to expose the weaknesses from which such explanations suffer. One

can refer, for example, to the considerable and highly successful efforts of Islamic mathematicians in the fields of geometry and trigonometry. One can relate the theoretical program of Islamic astronomers to the work of Ptolemy himself and to earlier ideals of Greek astronomy. One can point out the great complexity of the relationship between science and religion throughout Islamic history and in various parts of the Islamic world. And one can easily show the vacuousness of theories born of the spirit-of-culture approach. And, in fairness to those who have advanced explanations of these sorts, it must be said that they tend to be poorly informed (or worse) about Arabic science and, in many cases, about Islamic civilization—a fact that, unfortunately, does not seem to have discouraged their influence on minds that seek ready-made and perhaps comforting explanations.

What is wrong with these explanations, and others like them, is not their consideration of language, religion, and culture as factors in the formation of a scientific enterprise that consciously adopted earlier traditions with markedly different languages and religious and cultural values but, rather, their essentialist character, which has tended to prejudice or obstruct historical research. Now locality—that is, the character of being local—is an ineradicable or, if you like, an essential property of all historical events, but the actual where and when and how of any such events are happenings created by human effort. With the sure perceptiveness of a true historian, Richard Southern once described the process of acquisition and adaptation of Greek learning in Islam as “the most astonishing event in the history of thought.” The event is astonishing because it strikes us as unexpected, and the best way I know to explain the unexpected in history, insofar as it can be explained at all, is to try to understand it, not in terms of essences or spirits or inevitabilities, but as the outcome of choices by individuals and groups responding to their situations as they perceived and experienced them. Let me illustrate.

THE INTERSECTION OF ISLAMISM, ARABISM, AND HELLENISM IN NINTH-CENTURY BAGHDAD

The powerful drive that eventually led to the transfer of the bulk of Greek science and philosophy (as well as elements of the scientific thought of India and Persia) to Islam was launched as a massive translation effort that took place in the context of empire and under the patronage of the confident Abbasid court in Baghdad. Translations into Arabic had been made earlier, and these had been preceded in the Middle East by translations from the Greek into Syriac and Persian, but it was the Abbasids who mounted a concentrated translation effort soon after they came to power in the middle of the eighth century and who further organized and intensified their support during the ninth century. Under their predecessors, the Umayyads who ruled from Damascus (661−750), the Islamic empire already encompassed large areas—including Egypt, Syria, and Persia—that had come under the influence of Hellenism from the time of Alexander; and before the ninth century was over Islamic rule had reached Kashmir in the east and Khwarazm to the north. In the early Abbasid period the higher administration of the court itself was in the hands of cultivated Persians who had gained much favor and influence with the Abbasid rulers and whose intellectual interests inclined them to various forms of secular learning and to a rationalizing approach for understanding matters of religious belief. Some of these Persian officials acted as translators, especially from Persian, and in general they constituted an

important, politically influential part of Baghdad’s intellectual elites. Two other groups within the empire (and concentrated mainly in Syria, Iraq, and Persia) had maintained a long-established tradition of Hellenized Syriac learning. One consisted of Christian physicians and Christian theologians, who continued to pursue their interests in Greek logic and philosophy in scattered monastic schools; the other was the pagan Śabians of Harrān, in northern Mesopotamia, an ancient Semitic group whose astral religion connected them to Hellenistic astrology and astronomy and to Hermeticism. It was from these two last groups that the Abbāsids were able to recruit the scholars who carried out the translations of Greek medical, philosophical, and mathematical works into Arabic, either from pre-existing Syriac versions or directly from the Greek.

The survival of these pockets of Hellenic learning during the first centuries of Islamic rule in the Middle East and Asia, although scattered and limited at first in scope and appeal, ensured a certain continuity with the classical tradition—a continuity that was largely lacking, for example, in the case of the “Renaissance of the Twelfth Century,” when European scholars first had to journey to the edges of Western Christendom to acquire Arabic and Greek learning from across the borders with Islam and Byzantium. In the earlier Middle Eastern episode, this continuity meant the immediate availability of texts, in Greek or Syriac versions, and of translators already conversant with these languages and with Greek thought itself in a number of scientific, medical, and philosophical disciplines. And although much additional Greek material was later to be brought over the borders with Byzantium, the continuity with the Greco-Syriac tradition helps to explain the high level of competence, even sophistication, that characterized scientific writings in Arabic from an early period that overlapped the translation movement.

One might then say, and with much justification, that the stage was set, at a certain place and time, for the translation movement that quickly acquired unprecedented proportions—unprecedented not only in the Middle East but in the world at large. But in order to explain the momentum, scope, and multiple dimensions of that movement, it is necessary to go beyond the availability of favorable conditions, and even beyond the important consideration of practical expectations that must have loomed large at least in the minds of the Muslim patrons. Islamic religion had introduced a new ideology with sweeping and universalist claims. Already during the swift expansion of Islamic conquests, that ideology had come into direct contact with a large variety of creeds (Jewish, Christian, Zoroastrian, Mazdian, Manichaean, etc.) with which it inevitably collided and against which it had not merely to defend but—much more importantly—to define itself, often in terms borrowed from its opponents. The result was a huge intellectual ferment, centered especially in multicultural Iraq, to which the movements of Islamic theology, philosophy, and science owed their birth.

Or, should we not rather say, more accurately, that the creation of these fields of thought represented the responses of so many groups of individuals to aspects of what was, in the context of religion and politics and power and the variety of competing ways to salvation, a very complex and live intellectual atmosphere? With regard to the creation of the tradition of science and philosophy in Islam, I am tempted to borrow an obsolete term, aspecting, in order to refer to the way in which individuals in a given culture aspect another culture as they direct their gaze to the other from their own location. Aspecting in this sense is conditioned both by the interests, aspirations, and aptitudes of the aspecting individuals and by the accessible aspects of the viewed culture, that is to say, the aspects that happen to be disclosed to them by the accidents of history or by their further, determined effort. Thus, for example, through the Śabians of Harrān, Muslim thinkers were able to view
facets of Hellenistic thought that might not have been available to them by way of the Christian theologians, who had already made their own choices from their own standpoints. And, as has been plausibly suggested, the absence of Greek literature and Greek historiography from the translated corpus may be attributable to a lack of acquaintance or serious interest on the part of the Christian translators. In a similar way, the twelfth- and thirteenth-century Arabo-Latin translations in northern Spain were understandably limited to the types and the levels of the learning that was currently available in Al-Andalus, with all the features of that learning that had undoubtedly been shaped by a combination of circumstances peculiar to Al-Andalus.

The scholars of eighth- and ninth-century Iraq looked east to Persia and India and west to Greece and especially to Alexandria. Both looks deeply affected the character of Arabic science, especially in mathematics and astronomy, in both of which we find combinations of identifiable elements from the East and the West. But it was the westward gaze that proved most enticing and, as it turned out, most consequential. Some years ago I used the term appropriation to characterize the attitude of Muslim scholars and patrons who made it their business to get hold of and make their own what they called “the sciences of the ancients,” an expression that clearly revealed a sense of distance in time between themselves, as “the moderns” (al-muta‘akhkhirûn), and the appropriated legacy of “the ancients” (al-mutagaddimûn), even as the appropriators set about gaining possession of the ancient legacies with great energy. Without aiming here to unfold the full meaning of that sense of distance (which has frequently been misinterpreted and misused in modern scholarship), let me indicate briefly how it was understood and evaluated by some of those who promoted or participated in the appropriation drive of the ninth century.

I will not expand, not even briefly, on the role of the Abbasid caliph al-Ma‘mûn, whose contributions as a patron of astronomical research and as the one who turned the library of Greek philosophical sciences collected by his immediate predecessors into an organized center of translation are well known. But I must emphasize the significance of his deep involvement in a theological dispute that prompted him to initiate the “inquisition” against the conservative opponents of the Mu‘tazilite school of kalâm (or “theology”) that he favored. It is natural to think of a connection between al-Ma‘mûn’s support of the Mu‘tazilite emphasis on the role of reason in elucidating religious dogma and his championing

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of Greek science and philosophy. We are even given a hint of a contemporary interpretation of such a connection in a story that circulated in tenth-century Baghdad, if not earlier. The story reported a dream that the caliph was alleged to have had, in which none other than the pagan Aristotle appeared as an instructor to the “overawed” Commander of the Believers. In answer to al-Ma‘mūn’s question about the nature of the “good” (al-ḥasan), the Greek philosopher identifies its authoritative source in the first place with reason (al-ʿaql), in the second place with “the (religious) law,” and in the third place with what is accepted by “the majority of people” (i.e., the majority of legal scholars). In one version of the dream Aristotle ends by urging his Muslim student to uphold the unity of God (waʿalayka biʾl-tawḥīd)!7 Affirmation of the unity of God (tawḥīd) was the first article in the Muʿtaṣīlī creed, and it was in the name of divine unity, as interpreted by reason (ʿaql), that the Muʿtaṣīlī maintained the doctrine, which al-Maʿmūn and his two immediate successors sought to impose on the conservative legists, that the Qurʾān—as the speech of God—had not existed from all eternity but was created. The suggested connection between Greek rationalism and Islamic Muʿtaṣīlism is impossible to overlook.

Turning now from the patron al-Maʿmūn to leading Muslim intellectuals of the period, one quickly detects an attitude of openness and gratefulness to the recently imported wisdom, mingled with a feeling of high optimism and a certain trust in humanism that was quite pronounced. The major Arabic prose writer of the period, and one of the most influential figures in the history of Arabic literature, al-Jāḥīz (d. 869), was also the leader of a prominent branch of Muʿtaṣīlīmism named after him (al-Jāḥīziyya) and a reader of Aristotle. In one of his most important works, the monumental Book of Animals, which owed much to Aristotle and which he dedicated to the famous wazīr Ibn al-Zayyāt (who served the Abbasid court in the reigns of al-Maʿmūn’s successors, al-Muʿtaṣīm and al-Wāthiq [833–842, 842–847]), he thanks “the ancients” (i.e., the Greeks) for their considerable intellectual contribution to the scanty possessions of the people of his time and place and culture. He wrote, in a passage that is characteristic for its utter lack of inhibition or ambiguity: “Our share of wisdom would have been much reduced, and our means of acquiring knowledge weakened, had the ancients not preserved for us their wonderful wisdom, and their various ways of life, in writings which have revealed what was hidden from us and opened what was closed to us, thereby allowing us to add their plenty to the little we have, and to attain what we could not reach without them.”8

An exact contemporary of al-Jāḥīz, and arguably the single most important figure in this phase of appropriation, the celebrated Muslim philosopher, scientist, and mathematician al-Kindī (d. ca. 870), was a member of the Arab nobility (his grandfather, we are told, was amīr of al-Kūfa in southern Iraq). As a tutor to a son of Caliph al-Muʿtaṣīm, he was much closer to the Abbasid court than al-Jāḥīz. In his work On First Philosophy, dedicated to al-Muʿtaṣīm, we find strong acknowledgment of the accomplishments of ancient Greece that is combined with the assertion of truth as the universal good that must be sought out wherever it may be found, in addition to a clear concept of the growth of knowledge as a process of accumulation that requires the cooperative effort of different peoples and successive generations.9 These were the deep convictions of a true devotee,

and they carried with them an entire Hellenic or Hellenistic world view, a distinct concept of wisdom in both the theoretical and practical senses (also borrowed from the Greeks), and a sense of mission on the part of the author to do his utmost to disseminate the ancient and especially Greek heritage in his milieu. Both this world view and this concept of wisdom, as well as the universalist character of al-Kindî’s mission, are recognizable Hellenistic themes. But we all know better than to push the continuity thesis too far—especially not in the direction of blatant essentialism: to look on al-Kindî as a latter-day Hellene or Hellenist would be as helpful as the affirmation, found in Spengler’s Decline of the West, that the Pantheon built by Hadrian in the second century was the first mosque ever. Such a view of al-Kindî and other Muslims who shared his outlook in the ninth century would tear them away from their unique position in history and from the role they consciously and freely chose to assume in the context of their own culture. Al-Kindî’s mission, as he understood it, clearly reveals his adoption of the humanistic theme, his avowed intent being, as he said, “the perfecting of our [human] species.”10 But as one who lived in an Arabic culture, his immediate role, as he also conceived it, was to introduce and, he hoped, to convert his Arabic-reading contemporaries (ahl lisānīnā: the people who speak in our tongue) to the Greek wisdom that had captivated him—a task that he actually undertook to achieve by producing a huge number of Arabic epitomes and adaptations, with supplementary clarifications and additions when necessary, of a very large number of Greek disciplines of science and philosophy. This was a preposterously optimistic project for anyone to envisage; but not only was al-Kindî able to carry it out, whether singlehandedly or with the help of others, it proved to be remarkably successful—so successful, in fact, as to make him truly worthy of the reputation he quickly gained as one of the founders of the Arabic tradition in philosophy and science.

With these three pivotal figures in mind (and there are others that can be brought into consideration along with them), I am inclined to portray that crucial phase in the appropriation process as the accomplishment of individuals who experienced the intersection, at a certain place and time, of three major movements at work—namely those of Hellenism, Arabism, and Islamism. By viewing ninth-century Baghdad as a point of intersection in the manner I have tried to outline, I hope to render useless such questions as whether the scientific tradition then being established was essentially Arabic, Islamic, or Greek11 and to open the way for empirical research aimed at identifying the actual workings of these movements as revealed in the writings and records of those individuals who experienced and responded to them. No doubt there is reason here to celebrate the creative genius of a moment in the history of civilization, but my overriding aim is to direct attention to the complexity and richness of that extraordinary moment and away from the misleading “essences.”


Abundant richness also awaits the empirical investigator into the subsequent course of scientific activity in Islamic civilization. What I have just described is the attitude of certain

10 “idh kunnā ḥirāsan ’alā tatmînī nāw’inā”: al-Falsafa al-ʿilā, in Rasāʾīl, ed. Abū Rida, Vol. 1, p. 103. For the translation see Ivry, Al-Kindî’s Metaphysics, p. 58. See also Spengler, Decline of the West (cit. n. 2), Vol. 1, p. 211.
11 Ernest Renan, L’islamisme et la science, 2nd ed. (Paris: Calmann Lévy, 1883).
individuals who were favorably disposed to the imported knowledge and who played an active part in bringing about what later proved to be a long-lasting tradition. But, of course, a few first steps, even significant ones, might not have been followed by others in the same direction or with the same determination and vigor. And, indeed, there were other, contemporary individuals and groups whose markedly different or contrary attitudes and intellectual commitments, then and in later periods, did much to shape the course of Arabic science. As I turn now to later developments, our story acquires a degree of complexity that I cannot hope to convey in a lecture. But I shall try to give you a sense of it. It is a complexity that further illustrates the usefulness of the methodological concept of locality, and it will lead me at the end of my talk to pose the general question of whether, and in what sense, Arabic science should be investigated as a single enterprise. The story unfolds in at least three distinct but by no means isolated loci whose different structures and modes of operation and interaction have yet to be explored from the standpoint of our subject. These loci are the college or institution of higher learning, the royal or princely court, and the mosque. I shall arbitrarily ignore the hospital as a result of excluding medicine from my present account.\textsuperscript{12} 

I will begin with the college, and in order to bring you closer to an unfamiliar situation I will start with two general observations by way of comparison with more familiar episodes. The first is this: as far as science and philosophy are concerned, the European Renaissance of the sixteenth century was in part a reaction, which became more pronounced in the seventeenth century, against patterns of thought and argument associated with medieval “scholasticism.” In Islamic history, events followed the reverse order: the “renaissance” (if that is the right word) came first, in the ninth and tenth centuries, and a form of scholasticism followed, though not immediately and not uniformly in all parts of the Muslim world. My second observation points to another contrast between Islam and medieval Europe that is crucially important but more difficult to describe briefly. In Islam, whether in ninth- and tenth-century Baghdad, eleventh-century Egypt and central Asia, twelfth-century Spain, thirteenth-century Marāgha in northwestern Iran, or fifteenth-century Samarkand, the major scientific work associated with the names of those who were active at those times and places was carried out under the patronage of rulers whose primary interests lay in the practical benefits promised by the practitioners of medicine and astronomy and astrology and applied mathematics. Many of these practitioners were also prolific writers on “philosophy,” a mode of thinking known by the Arabicized term \textit{falsafa} and characterized to a large extent by a mixture of Aristotelian and Neoplatonic doctrines and forms of argument—the kind of mixture we find, for example, in the works of al-Kindī, al-Fārābī, and Avicenna. In those circumstances science and “philosophy,” or \textit{falsafa}, were secular activities that were practiced, developed, and propagated as rational inquiries completely independent of any religious authority—which, of course, did not prevent the proponents of this autonomous, self-legitimizing mode of thinking from offering their own rationalistic (i.e., Hellenic) interpretations of religious doctrines such as revelation or prophecy or providence and of religious institutions such as law. After all, \textit{falsafa} was an all-embracing world view that claimed the right to scrutinize and account for everything within the sphere of human experience, including religious experience. In

\textsuperscript{12} The only “excuse” for this exclusion is to avoid further complicating an already complex picture. No story of Arabic/Islamic science or philosophy is complete without taking into account their relation to medical thought, the effect of medical patronage, the place of science and natural philosophy and logic in the institutions of medical education and practice, and the role of Galenic writings as a source of ideas and doctrines that shaped the minds and attitudes of Islamic philosophers and scientists, as well as physicians.
one case among the prominent devotees of falsafa, that of al-Kindī, a serious compromise was made by renouncing the Greek doctrine of the eternity of the world in favor of creatio
ex nihilo. But unlike most of their Christian counterparts in medieval Europe, Islamic philosophers (the self-styled falāṣifa) and philosopher-scientists in that Greek sense were not “theologians” or members of religious orders. The one major exception, of sorts, is the twelfth-century Andalusian Averroes, who came from a celebrated traditional family of Mālikite jurists and practiced the Mālikite version of Muslim law as a judge, but who nevertheless believed himself to have inherited the mantle of Aristotle. I shall come back to him later.

Now, Islamic “theology,” or what has come to be known in Western scholarship by this name, followed a different course—with important, indeed far-reaching consequences for the development of both science and falsafa. It began to make a conspicuous appearance in the eighth century (the second Islamic century), well before the patronized translation movement got under way, as the activity of spontaneously sprouting groups of Muslim intellectuals in the urban centers of Basra and Baghdad who immersed themselves in probing discussions (kalām: speech, discussion, argument), obviously driven by their interest in current religious and political controversies. They gradually developed somewhat varied and sometimes seemingly indecisive but sophisticated and sophisticatedly argued doctrines concerning a comprehensive array of subjects that ranged all the way from God and his relation to man and the world, to questions of epistemology and morality and political leadership, to subtle and difficult speculations about the ultimate constitution of all created being, which they characteristically proposed to understand in atomistic terms. The falāṣifa later dubbed these kalām practitioners as religious apologists, thereby seeking to downgrade their rivals or, if possible, to circumscribe their role by subsuming their enterprise under the authority of falsafa.\textsuperscript{13}

There can be no doubt that the early practitioners of kalām, the mutakallimūn, were influenced by a multiplicity of pre-Islamic traditions in ways that still remain mostly veiled in obscurity. But whatever the remote sources of their ideas, and despite their fundamental concern with the elucidation and critique of religious tenets, it is my conviction (which I share with a few others) that the discourse of the early “school” of the Muʿtazila, the one favored by al-Maʿmūn, and of the later and subsequently dominant Ashʿarites, represents an important turn in the history of philosophical thought—one that gave rise to new styles of thinking that seriously challenged the Aristotelianism and Neoplatonism of falsafa by proposing a thoroughgoing atomism that viewed the world as a creative process. It was this new philosophy, the “philosophy of the kalām,” as Harry Wolfson called it,\textsuperscript{14} that, in the Ashʿarite version, later found its way into the colleges of higher education, the so-called madrasas that ultimately spread wide and far over the Islamic world as endowed or charitable institutions, having been first introduced on a large scale in the eleventh century by the Sunni Saljūqs in Iraq and Persia as part of a political agenda and in response to the Ismāʿīlī propaganda emanating from Fāṭimid Egypt and Syria.

The madrasas, it should be noted, were first conceived of as primarily schools of law,


\textsuperscript{14} Harry Austryn Wolfson, The Philosophy of the Kalām (Cambridge, Mass./London: Harvard Univ. Press, 1976). The view of kalām as religious apologetics has been prevalent in modern literature but is currently being revised. See Richard M. Frank, “The Science of Kalām,” Arabic Sciences and Philosophy, 1992, 2:7–37; and Sabra, “Science and Philosophy in Medieval Islamic Theology.”
an emphasis that they retained throughout their history.\textsuperscript{15} But, as creations of private endowments, they generally enjoyed a degree of informality that allowed for a variable range of intellectual pursuits that depended on local circumstances and the interests of their professors and their sponsors. Many, perhaps a large number, of the madrasas included some teaching in arithmetic, algebra, astronomy, and logic as part of the intellectual equipment of the practicing jurist, along with the indispensable disciplines of language and rhetoric. Kalām, as a study of the “fundamental tenets of religion” (usūl al-dīn), performed the dual function of supplying a superstructure of theory for the rest of the “religious sciences” as well as a substitute for Greek metaphysics and natural philosophy.

Combining these two general observations should now help us to appreciate the following result. The sciences of the Greeks, which were first welcomed in Islam along with Greek theories of cosmology and epistemology and metaphysics (be they Hellenic or Hellenistic), eventually came to be confronted in the madrasas by a homegrown religious philosophy that claimed to develop viable alternatives to the Greek paradigms. That much we can say in light of what we already know. But there is no end to the questions that have yet to be examined. When and where and in what circumstances did that process take place? Was it one process or many? How did kalām manage to subdue falsafa, given the tentative beginnings of the former and the originally strong and full-grown nature of the latter? How much, if anything, of falsafa doctrines and forms of argument was absorbed into kalām? How did falsafa react to the assault of the mutakallimūn, given that falsafa continued to pursue its activities long after the advent of the madrasas, at least in some parts of the Muslim world? And—the question of special importance for the historian of science—what was the effect of the kalām point of view on the dissemination and development of scientific disciplines such as cosmology and astronomy, about which the mutakallimūn had a lot to say as an integral part of their own world view?

None of these questions can be answered a priori. They are all empirical questions that require empirical research. Some of my colleagues, I am happy to say, are now beginning to tackle them in earnest. Others are reluctant to embrace them, being afraid of the possible danger of diverting too much attention from the vast quantities of scientific texts that remain to be edited and analyzed. The skeptics have a point, and I share their concern. But this is not an either/or matter. As for the argument that “we do not yet know enough to ask the big questions,” my answer is this: it is only by attempting to formulate appropriate questions that can be fruitfully examined in light of what we now know that we make it possible for others to come up with deeper and more probing questions in the future. We do not know much (that is for certain), but the day when we know “enough” will never come. On the other hand, by altogether abandoning all programs of full-fledged historical research, we only tempt others to fill the vacuum with easy and useless essentialist generalizations.

The madrasas were not, therefore, in general a locus where scientific research was promoted for its own sake, but one in which science was interpreted and judged and

\textsuperscript{15} The literature on the madrasa is growing rapidly, but see especially the wide-ranging studies of George Makdisi: “Muslim Institutions of Learning in Eleventh-Century Baghdad,” Bulletin of the School of Oriental and African Studies, 1961, 24:1-56 (rev. by A. L. Tibawi, ibid., 1962, 25:225–238), and The Rise of Colleges: Institutions of Learning in Islam and the West (Edinburgh: Edinburgh Univ. Press, 1981). Most of the recent publications are concerned with the Mamlūk period (for which there is abundant material), but they have not yet directed special attention to the question of the place of science and philosophy in the madrasas. This must be true in part to the long-held assumption that science and philosophy had no place in the madrasas, which is not quite true, as is now being realized.
presented to a large group, indeed the vast majority, of educated Muslims. When we talk of scientific advance in Islam, whether in mathematics, astronomy, or experimental science, we usually have in mind the contributions of men who carried out their work outside of the madrasas with the support of kingly patrons—men like al-Khwārizmī, al-Khayyāmī, Ibn Yūnus, Ibn al-Haytham, al-Bīrūnī, al-Ṭūsī, and al-Shīrāzī. As always, there were exceptions—sometimes important ones, especially in the later period—and in some cases the systems of patronage and madrasa even seem to merge, either partially, or even completely, as for example under Ulugh Beg’s initiative in fifteenth-century Samarkand. Such exceptions should direct our attention to the significant overlap among all three loci of court patronage, college, and mosque. But the general picture of scientific advance in Islam as a patronized activity holds.

What we are still far from understanding is how patronage worked in contexts that obviously differed from one center of activity to another. Let me give an example with reference to two or three situations about which we know a little more than about the rest. Consider again the pagan sage, Aristotle, who was said to have inspired Caliph al-Ma’mūn and with whom the Mālikite Muslim jurist Averroes identified himself. In both cases we encounter acceptance of the authority of an alien thinker and of the intellectual values he represented. In both cases a Muslim theological context was involved: Mu’tazilite kalām in the earlier episode, and the religious ideology of the Almohad dynasty in the later Andalusian episode. But the theological commitments were different in the two cases, with rather different implications for the place and authority of the law, and so were the patterns of patronage. The differences were, moreover, enhanced by an emphatic self-conscious Andalusian identity vis-à-vis the rest of the Islamic world. It is not surprising that Averroes, as the intellectual who responded most powerfully to this Andalusian situation, should develop a new theory of religious authority, a totally negative attitude to kalām, and a new valuation of his adopted Aristotelianism that set him against his Peripatetic predecessors and earlier mathematicians in the eastern part of the Islamic world. It is, therefore, with reference to this special context in all its geographical, political, and intellectual particulars that we should try to gain a historical understanding not only of Averroes’ rebuttal to the attack launched by the Eastern al-Ghazālī against the falāsīfa, but also of his important and explicit divergences from fellow-faylasūfs like Avicenna or from a recognized mathematical authority like Ibn al-Haytham and of his ultimate rejection of the hitherto-dominant Ptolemaic astronomy.16

Similar, or greater, contrasts with regard to attitudes, patterns of relations between patron and client, and implications for the practice of science are what we should expect to find as we turn our attention to later periods. For example, soon after the Mongol Ilkhanids had captured Baghdad in 1258, thus bringing the Abbasid caliphate to an end, their leader Hūlagū was persuaded to establish an observatory at Marāgha in northwestern Iran, an event that marked the beginning of one of the longer-lasting and important episodes in the history of Arabic science. Most of the scholars who were soon to be gathered at Marāgha were Muslims (there are reports of one or more Chinese scholars). The man put in charge of organizing the new enterprise was Naṣīr al-Dīn al-Ṭūsī, a Persian from Tūs with serious interests in Shi‘ite theology and Avicennan philosophy. (See Figure 1.) At age fifty-five when he surrendered himself to the Mongols upon their capture of the Ismā‘īlī stronghold of Alamut, he was already famous as a scholar and known to the Mongols as a competent astronomer and astrologer. Two other scholars, both of them Sunnis, were brought over

16 Sabra, “Andalusian Revolt against Ptolemaic Astronomy” (cit. n. 5).
from Syria. One of them, Mu‘ayyad al-Dīn al-‘Urdī, had a reputation as a building engineer and instrument-maker. The other, the mathematician Muḥyī al-Dīn al-Maghribī al-Andalusī, was captured by the Mongols during their campaign in Syria in 1259–1260. He managed to save his life only by presenting himself to his captors as an astrologer who could be of use to “the lord of the earth,” the great Mongol Khān.17 The Mongol patron of the astronomical enterprise at Marāgha was not Muslim, and his interest in the work of the observatory was undoubtedly astrological. The immediate goal was to produce a new

set of astronomical tables, based on new observations, of the type that had been used by Arabic astronomers and astrologers for planetary predictions since the time of al-Ma'mūn. The Zīj-i Il-Khānī, as the new Persian handbook came to be known, was not completed until 1272, after Hūlagū’s death. But in the meantime, and for several decades afterward, the scholars at Marāgha and nearby Tabrīz were able to pursue their individual interests in theoretical astronomy and in various branches of mathematics. It was in this singular situation that the aporetic research in planetary theory, which was initiated by Ibn al-Haytham before the middle of the eleventh century and had attracted the attention of a few individual scholars in Asia and Syria, first found a sustaining atmosphere; and it was from here that this type of research later spread further east, south, and west, where it was carried on in different terms or with different emphases as scholars with different commitments responded to changing contexts. (See Figure 2.)
The phenomenon of the mosque as a significant locus of scientific activity came into being at about the same time as the establishment of the Ilkhānid rule in Iran and Iraq, being associated with the ascension to power of the Mamlūks in Egypt and Syria in 1250. Most of what is now known about this important phenomenon is due to David King, whose work over the last twenty years has been responsible for putting this phenomenon on the map of Arabic science. It was the longest-lasting episode within the tradition of Arabic/Islamic science, having continuously endured in some of the major mosques all the way up to the nineteenth century, and it possessed interesting features that distinguish it in several ways from court patronage and the madrasas, the two other loci of consequence.

Though primarily a place of worship, the mosque, from its inception, and as distinguished from the madrasa that was sometimes attached to it, often served as a forum for propagation and discussion of subjects related to Arabic language, grammar, and rhetoric, as well as the vital issues of law, religion, and politics. Through the introduction, apparently for the first time under the Mamlūks, of the office of muwaqqit, the timekeeper in charge of regulating the times of the five daily prayers, a place was created for the utilization of one form of scientific knowledge in a permanent religious institution.

Strictly speaking, it would be wrong to consider the muwaqqit a “professional” astronomer. His institutional role in the mosque was not to pursue the goals of astronomy as these had been defined and elaborated by Arabic astronomers since the ninth century but, as is clearly indicated by his status title, to offer reliable guidance to his local Islamic community with regard to definite religious observances (mainly prayer times) as specified by religious law. This function the muwaqqit nonetheless performed in his capacity as an expert in what was called “the science of reckoning time” (ʿilm al-miqāt) by means of exact astronomical computations, and this distinguished him from the traditional muʿezzin (the man who called for prayer), who relied on traditional prescriptions. The main task of the muwaqqit was therefore to use the methods of spherical astronomy in order to construct tables, usually computed for a certain locality or latitude, that would enable anyone who could operate a simple observation instrument (such as an astrolabe or a quadrant) to determine the time of day or night from the altitude of the sun or a star. A muwaqqit might also possess the skill to construct such instruments. And some distinguished muwaqqits in the thirteenth and fourteenth centuries accomplished the impressive feat of providing universal solutions of timekeeping problems (indeed, all problems of spherical astronomy) for all latitudes. One muwaqqit, the fourteenth-century Ibn al-Shāṭir (d. ca. 1375), who was attached to the Umayyad mosque in Damascus, ventured into the area of theoretical astronomy to produce the most complete solution to the equant problem, which Ibn al-Haytham had forcefully pointed out as a threat to the principles of Ptolemaic astronomy and which was diligently pursued by mathematical astronomers in the thirteenth century. These were all accomplishments that must be regarded as accomplishments in astronomy proper, regardless of their institutional setting. And the same can be said of other equally impressive investigations aimed at determining the direction of Muslim prayer. As in the case of timekeeping, these investigations also culminated in universal solutions for all latitudes.

And yet it is noticeable, as King has pointed out, that the legal scholars and interpreters

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19 The distinction has to be maintained despite occasional or even frequent overlappings, as, for example, when a local ruler was responsible for the appointment of a favored professor in a madrasa.
of the religious law continued to apply the simpler considerations, based on observations of twilight and horizon phenomena (rising and setting) or of shadow lengths, leaving alone the sophisticated mathematical treatises, which they "generally considered to be too complicated or even completely irrelevant."20 This is not really surprising (mathematical precision need not be considered a prerequisite of religious piety!), but it does render problematic the concept of the muwaqqit's mathematical work as "service to religion." On the other hand, the theoretical triumph of Ibn al-Shātīr in planetary theory does not seem to have elicited serious attention from other contemporary muwaqqits, and this appears to be the result of the fact that their institutional position did not demand or encourage theoretical ventures for their own sake. Such paradoxes may simply reflect our present, inadequate knowledge of the circumstances in which a new institutional structure brought together mathematical and religious interests. But whatever the correct understanding of these paradoxes might be, it would be gratuitous to regard the work of the muwaqqit in aiding religious ritual as constituting "the essence of Islamic science" (as King puts it)21 or even as the most revealing aspect of scientific activity in Islam. To propose such a view may have the advantage of highlighting the uniqueness to Islamic civilization of a certain emphasis on some programs of astronomical research. But the disadvantages of this proposal are also glaringly conspicuous. It disregards the full extent of scientific research in Islam, and it ignores the characteristic complexity of Islamic civilization itself by neglecting the variety of religious attitudes with regard to the status, the function, and the value of scientific knowledge. And it might appear to equate "Islamic science" with narrowly circumscribed programs that largely developed within the confines of an institution with no commitment to "science" as such, and this alone would tend to obstruct or prejudice vital questions about scientific practice in Islam by identifying a single locus of activity with a widespread and extremely complex phenomenon. And, of course, it would again open the way into the trap of essentialism.

To come finally and very briefly to the general question formulated earlier: Was Arabic science one or many? A similar question has sometimes been asked with reference to Islamic art, where manifest varieties of styles and functions are displayed in the artifacts and architectural monuments of the vast Islamic world. As far as science is concerned, it seems to me that important considerations lead us to say that we have to do with a single, unitary tradition. These are considerations of language, which—for science and philosophy—was for the most part one language (Arabic), and of Islamic religion as an ever-present point of reference though not always a point of departure, in addition to considerations of the dominance of dynastic rules over large regions for extended periods of time and the remarkable ease of movement and communication all through the Muslim world—a feature itself connected to religion and law and language. And, with regard to communication of learning, we must also keep in mind that crucial Chinese invention, paper, which took the whole Islamic world by storm from the moment of its appropriation in the middle of the eighth century.

One example will have to suffice as an illustration of what I mean by these remarks. Writing in fourteenth-century Damascus, Ibn al-Shātīr linked his studies in theoretical astronomy to those of earlier mathematicians, four of whom had worked in thirteenth-century Marāgha, one in eleventh-century Egypt, two in twelfth-century Spain, and two

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21 Ibid., p. 245.
who originated in thirteenth-century Syria and North Africa. All had written in Arabic, the language in which Ibn al-Shāṭir also wrote. The example is representative of situations that existed before and after Ibn al-Shāṭir, though there were cases in which Persian and Turkish were the languages of composition, especially in later times. But once we direct our attention to situations, as distinguished from tradition, our picture and our problematic will change with every case, as we turn from one set of circumstances to another in which individual choices are made with reference to specific problems proposed by specific contexts. Not, of course, that tradition and individual response are separable: on the contrary, the former provides an inseparable part of the intellectual context in which the other must take place. When I started to write this talk I hoped to be able to illustrate and perhaps also to characterize in some general terms the interplay of tradition and individual response with reference to one or two episodes of Arabic science. In the end I am forced to leave that subject for another time and place.