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XII Century Natural Philosophy in the Islamic World

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Abstract: In the first part of this essay, we will develop an idea of the Islamic science, which makes it possible to understand its integration in the field of Metaphysics. In the second part, we will develop some key notions in ibn Sina's Natural Philosophy, which shows how the human reality is linked to the scientific conception of nature, and completely inserted in it, as opposed to what occurs in the Modern Scientific Paradigm.

Islamic science embraces a wide range of intellectual life, from the study of plants to algebra, which was developed over more than a thousand years by many races and people spread across the middle of the planet from Spain and Morocco to East Asia. As a consequence of its traditional character, such science is less limited in both its goal and contents than modern Western science is. The Islamic sciences that will be taken into account in this paper are related to the study of the cosmos; *i.e.*, we shall not consider here the religious and philosophical sciences. However, a further severe limitation is also required: we shall only consider the sciences related to the domain of physics, and it will be specified in due time what meaning we assign to this term. Although this limitation has to be taken into account, we must not forget that the Islamic sciences related to the study of the cosmos also include the domains of nature, the soul, and mathematics. Due to their symbolic qualities, they are also closely related to metaphysics and art; and, thanks to its practical dimension, they are in contact with the social and economic life of the community, as well as with the divinely-inspired law that rules Islamic society. When all these factors are considered, the vastness of the subject which needs to be acknowledged by the researcher of Islamic science becomes evident, as does the reason why a complete study of it is currently lacking.

The influence exerted by Islamic science over the Latin, Medieval and Renaissance Western worlds gave rise, from the 18th century onwards, to several investigations in European languages on the matter. It was only in 1975 that a complete bibliography on Islamic science was first published.[1] In addition to this, there is a huge amount of textual material written in Islamic languages. Nevertheless, the subject remains unknown to a large extent and, lingering in libraries around the world, many treatises on the Islamic sciences have barely received any attention yet.

Based on the results of the investigations already undertaken, various researchers have tried to write histories of–Islamic science. Names such as Sarton and Mieli, among others, and more recently, Sezgin, are to be remembered. S.H. Nasr's work must also be mentioned, as it combines a

[1] *Cf.* Nasr, S.H., *An Annotated Bibliography of Islamic Science*, Tehran: Cultural Studies and Research Institute, 1975.

morphological perspective with a historical one for the study of Islamic science, and it also includes selections of texts translated into English.[2]

I. General Introduction to an Idea of Islamic Science

It is of the greatest importance to understand that it is impossible to undertake an appropriate research on Islamic science without a suitable

[2] *Cf.* Sarton, G., *Introduction to the History of Science*, Baltimore: Williams and Wilkins, 1927-1931; Sarton, G., *Ensayos de historia de la ciencia*, México: UTEHA, 1968; Mieli, A., *Panorama general de historia de la ciencia*, Buenos Aires: Espasa-Calpe, 1952-1958; Daumas, M., *Histoire de la science*, Paris: Gallimard, 1957; Taton, R., *Histoire genérale des sciences*, Paris: PUF, 1957-1964; Mason, S.T., *History of the Sciences*, New York: Collier Books, 1952; Metraux, S. and F. Crouzet, *The Evolution of Science*, New York: Mentor Books, 1963; Serres, M., *Historia de las ciencias*, Madrid: Cátedra, 1998; Holt, P.M., Ann K.S. Lambton and B. Lewis, *Islamic Society and Civilization*, Cambridge: Cambridge University Press, 1970; Schacht, J. and C.E. Bosworth, *The Legacy of Islam*, Oxford: Oxford University Press, 1974; Ahmad, K., *Islam. Its Meaning and Message*, Qum: Centre of Islamic Science, 1978; Balta, P., *Islam. Civilización y sociedades*, México: Siglo XXI, 1994; Jayyusi, S.K., *The Legacy of Muslim Spain*, Leiden: Brill, 1992; Schuon, F., *Comprendre l'Islam*, Paris: Gallimard, 1961; Gibb, H.A.R., *Islam*, Oxford: Oxford University Press, 1978; Gauderoy-Demombynes, M., *Muslim Institutions*, New York: Barnes and Noble, 1961; Makdisi, G., *The Rise of Colleges*, Edinburgh: Edinburgh University Press, 1981; Suter, H., *Die Mathematiker und Astronomen der Araber und ihre Werke*, Ámsterdam: APA/Oriental Press, 1981; De Boer, T.J., *The History of Philosophy in Islam*, New York: Dover, 1967; Goichon, A.M., *La distinction de l'essence et de l'existence d'après Ibn Sina*, Paris: Desclée de Brouwer, 1937; Goichon, A.M., *Lexique de la langue philosophique d'Ibn Sina*, Paris: Desclée de Brouwer, 1938; Goichon, A.M., *Vocabulaires comparés d'Aristote et d'Ibn Sina*, Paris: Desclée de Brouwer, 1939; Goichon, A.M., *La philosophie d'Avicenne et son influence en Europe médiévale*, Paris: Maisonneuve, 1951; Garbers, K., *La matemática y la astronomía en la Edad Media islámica*, Madrid: CSIC, 1954; Arnaldez, R. and L. Massignon, *La science arabe*, Paris: PUF, 1957; Dunlop, D.M., *Arabic Science in the West*, Karachi: Pakistan Historical Society, 1958; Afnan, S.F., *El pensamiento de Avicena*, México: FCE, 1958; Rosenthal, F., *Das Fortleben der Antike im Islam*, Zurich: Artemis, 1965; Sharif, M.M., *History of Muslim Philosophy*, Weisbaden: Harrassowitz, 1963-1966; Sezgin, F., *Geschichte des arabischen Schrifttums*, Leiden: Brill, 1967; Nasr, S.H., *Science and Civilization in Islam*, Harvard: Harvard University Press, 1968; Nasr, S.H., *Three Muslim Sages*, Cambridge, Mass.: Harvard University Press, 1969; Nasr, S.H., *Islamic Science*, Westerham: World of Islam Festival, 1976; Nasr, S.H., *Islamic Cosmological Doctrines*, London: Thames and Hudson, 1978; Montgomery Watt, W., *The Influence of Islam in Medieval Europe*, Edinburgh: Edinburgh University Press, 1972; Al-Hassan, A.Y. and D.R. Hill, *Islamic Technology*, Cambridge: Cambridge University Press, 1986; Endress, G., *Die Wissenschaftliche Literatur im Islam*, Weisbaden: Reichert Verlag, 1992; Beas, C., 'La transmisión de la ciencia antigua al mundo islámico según el Catálogo de an-Nadim', in: *Areté*, VII (1995); Beas, Carlos, 'Las matemáticas y la astronomía en el mundo musulmán según el Catálogo de an-Nadim', in: *Areté*, VIII (1996); Cruz Hernández, M., *Historia del pensamiento en el mundo islámico*, Madrid: Alianza Editorial, 1996; Vernet, J., *Lo que Europa debe al Islam de España*, Barcelona: El acantilado, 1999.

knowledge of Islamic religion, for the latter is the force that gave life to a vast culture, one of whose fruits is science.[3] These sciences did not spring up by chance among the people who professed the Islamic faith; on the contrary, they were produced in their proper form by Muslims who breathed the air of the Islamic world.[4] Islamic science arose when the spirit that animates the Koranic revelation merged with the sciences that came from the various cultures of which Islam is an heir. Within the Islamic tradition, those cultures underwent a profound transformation that moulded them into a new substance which was, in its time, simultaneously an extension of what already existed, as well as a new beginning. The cosmopolitan nature of Islamic culture stems from the universal character of Islamic revelation and is reflected in the geographical expansion of the Islamic world. Such nature enabled it to produce the first science in human history with a truly international character. Islam received the intellectual heritage of the great cultures that preceded it – except for those which originated in the Far East – and thus became a hub within which different intellectual traditions regained a new impulse by being transformed within a new spiritual universe. This feature can never be stressed enough, as many people from the Western modern world mistakenly believe that Islam was no more than a bridge that transported the ideas of the Ancient world into the West. Nothing is further from the truth, for no idea, no theory or doctrine, entered the world of Islam without being integrated into it and thus becoming transformed.

Before the Islamic sciences appeared, various cultures from the past had created sciences dealing with different aspects of reality that had achieved various levels of perfection. The huge proto-history of science that is leading us nowadays to the farthest corners of human history, in spite of its continual revelation of amazing accomplishments,[5] is not the immediate concern of this paper. Instead, in what follows we will focus on the immediate predecessors of Islamic science. Two large cultures, Egypt and Mesopotamia, had already produced medicine and mathematics of great quality before the Greek philosophers and scientists were able to reflect upon them and make contributions of their own. Located within this long tradition of the study of the skies and the realm of nature, the ancient Greeks were responsible for the discoveries and works of Thales, Pythagoras, Plato and Aristotle in a relatively short period, before the centre

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[3] *Cf.* Nasr, S.H., *Science and Civilization in Islam* e *Islamic Cosmological Doctrines*, *o.c.*

[4] *Cf.* Schuon, F., *o.c.*; Gibb, H.A.R., *o.c.*

[5] Consider the revelations made by the most recent archaeological investigations.

of their scientific activity moved to Alexandria. Then, when the Hellenic power was declining and the Ancient Egyptian culture was coming to its end, a new synthesis of the cultural traditions of Greece, Egypt and the Eastern world took place, engendering one of the most prolific periods in the history of science. This was the era of Euclid, Ptolemy and Galen, all figures which were to become known in Islamic world. In order to understand Islamic science, it is important to bear in mind that the Hellenistic heritage arrived to the Islamic world from Alexandria, which is why Plato was known through the ideas of the Neo-Platonists, and Aristotle from the comments of Alexander of Aphrodisia and Themistius. In its combination of mystical elements and strict logic, in the way it synthesises various scientific traditions, and in its habit of arranging the sciences in a hierarchy dependant upon the way of knowing, Alexandrian science is a kind of historic anticipation of the science of Islam.

Nevertheless, the transmission of the Hellenistic legacy into Islam was not direct. Many centuries of Christianity lie between the golden age of Alexandria and the rise of Islam. Alexandria was going to become a significant intellectual hub of early Christianity; later on it would suffer the consequences of its rivalry with other centres of the Christian power, especially Constantinople and Antioch. At length, its scientific activity would be wiped out under the pressure of the Byzantine emperors, a thorough extinction symbolised by the murder of Hypatia, daughter of Heron, in one of the city streets, as well as by the fire of its fabulous libraries.[6] However, before this tragic ending took place, much of the intellectual apparatus of Alexandria had been moved to Antioch due to the fierce rivalry between the Monophysite and the Nestorian churches on the one hand, and the Byzantine church on the other.[7] Subsequent rivalries between Byzantines and Sasanids, who obviously supported any schismatic movement against the Byzantines, would force the centres of study of the Eastern churches further to the East, to Edessa and Nisibis, and, finally, to the limits of the Persian Empire.

The Christian centres of the Near East – where Greek was being studied and Syrian was used as the language for science and erudition – were not the only channels that linked the intellectual lives of the Ancient world and the Islamic world. A religious form known among the Muslims as

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[6] It has been demonstrated in recent decades that the libraries of Alexandria had been destroyed before the Islamic conquest of Egypt.

[7] *Cf.* O'Leary, D., *How Greek Science Passed to the Arabs*, London: Routledge, 1949; Walzer, R., *Greek into Arabic*, Oxford: Bruno Cassirer, 1962.

Sabeanism was cultivated in the town of Harran.[8] It combined elements taken from the ancient Babylonian religion with mystery aspects from the Greek tradition. The people of Harran, therefore, inherited the teachings on astronomy and astrology of the Babylonians, as well as the teachings of Pythagoreanism and Hermetism. Regardless of the Christian centres of study, they transmitted to the Muslims many aspects of the ancient intellectual legacy, and, separately to the Greek legacy, they also transmitted certain aspects of Babylonian mathematics and astronomy that are reflected in Muslim sources and cannot be found in Greek sources.

As for the Persian world, it also bequeathed many sciences to Islamic culture, some of which were their own and some which were originally from India and Greece. During the Sasanid period, the Persians transformed the city of Jundishapur, which nowadays lies near the Persian city of Ahyaz, into a university centre that gradually evolved until becoming the heir of Antioch and Edessa, a place where researchers from all over the world could meet. By the time of the fall of the Sasanids it was, undoubtedly, the most important centre of research in Western Asia, especially in medicine. Jundishapur was, indeed, a meeting place in which Persians, Greeks and Indians researched together. In many fields, this school, more than any other, was the link between–Islamic science and the Ancient world. While the Persians cultivated a specific interest in the areas of astronomy and pharmacology, they eagerly studied the Indian and Greek sciences.

Persia made great contributions to almost every aspect of Islamic culture, becoming one of its main centres and assuming a central function in its creation. In the domain of science, Persia had a triple transmitting function: it bequeathed its own scientific tradition to Islam, as can be seen in such works as the *Royal Astronomical Tables* (*Zij-i shahriyar*); it made accessible certain aspects of Greek erudition to the Muslims, thanks to the translations into Pahlavi or Syrian that were carried out in Persian centres of research such as Jundishapur; and, finally, it transmitted to Islam several Indian sciences that had been developed during the Sasanid period, especially in the areas of medicine, astronomy, and natural history. A particularly notable example of this last function is the book *Kalilah wa Dimna*, which was first translated from Sanskrit into Pahlavi, and then, by

[8] *Cf.* the classical work by Chwolson, D., *Die Ssabier und der Ssabismus*, Saint Petersburg: Buchdruckerei der Kaiserlichen Akademie der Wissenschaften, 1856; and also, Drower, E.S., *The Mandeans of Iraq and Iran*, Oxford: Clarendon Press, 1937. There is also a new impression of the monumental work of Chwolson in Amsterdam: Oriental Press, 1965.

ibn Muqaffa', into Arabic, quickly becoming a source of Muslim natural history.[9]

As for the legacy of India, its scientific tradition, especially in mathematics, astronomy and medicine, reached Islam not only through the Sasanid Persia, but also due to some erudite Indians that were invited to Baghdad and other Islamic intellectual centres as well. Indian sciences certainly found a preliminary path into the Islamic world through the writings of al-Biruni in the 5/11th century[10], and shortly afterwards with the various works of Amir Khusraw. However, Islamic science can be properly said to have originated from the translation of certain texts on mathematics and astronomy, such as the *Brahmasphutasiddhanta* by Brahmagupta, and some other medical works on drugs and poisons.

Finally, although there are no traces of Chinese scientific tradition at the moment of birth of the Islamic sciences, and we must wait until after the Mongolian invasion for the 'official' transmission of the Chinese scientific works through Persian and Arabic, there is no doubt that some scientific contact was made. The transmission by the Muslims of significant Chinese technological inventions, such as paper, and the presence of certain elements which are definitely Chinese, like the Ming-Tang in the early Muslim alchemy, bear witness to the fact that their mutual relations were not merely limited to commercial transactions.

The process of translation of the sciences of ancient cultures into Arabic (from languages such as Greek, Syrian, Sanskrit, and Pahlavi) is one of the most remarkable examples of cultural transmission in human history, comparable only with other processes of translation and transmission such as the translation of the *Buddhist Sutras* into Chinese, or of the Arab works into Latin. However, both in terms of quality and quantity, Arab translations surpass, perhaps, every other major episode of cultural translation. Without external compulsion, urged mainly by the domestic thirst for knowledge – in accord with the intellectual nature of Islamic tradition – the still-young Islamic world channelled its energies towards a vast translating enterprise, establishing academies for this purpose such as Bayt al-Hikmah of al-Ma'mun. The existence of religious minorities especially suitable for the process of translation within the enclosure of Islam (dar al-Islam) undoubtedly facilitated this task, and the

9 *Cf.* Nasr, S.H., 'Natural History, in: Sharif, M.M., *o.c.*

10 Here, and in what follows, the first number shall indicate the century in the Muslim era, whereas the second number will correspond to the century in the Christian era.

project was also aided by the existence of various scientific works which had been translated into Syrian, a Semitic language closely related to Arabic.[11]

Certainly, the translation into Arabic of the majority of the important ancient scientific works within a period of 150 years (from the 2nd/8th century until the 4/10th century) was not an easy task. Thanks to certain masters in the art of translation such as Hunayn ibn Isaac, and the coordinated effort of caliphs, princes, and viziers, the works of Hippocrates, Aristotle, Theophrastus, Euclid, Ptholomeus, Dioscorides and Galen, among many others, could be translated with precision into Arabic. Furthermore, this was undertaken with the assistance of an oral tradition that has attained translations often closer to the original than many modern translations.[12] Due to this movement, Arabic became the most important scientific language of the world for many centuries, without omitting the great importance of Persian, especially during subsequent periods of Islamic history. This linguistic groundwork effectively prepared the growth of Islamic sciences.

The promotion of Islamic sciences was also dependent upon the existence of a wide educational system that covered both formal and informal education, a system that fostered an inclination towards knowledge and its transmission. This educational system was based upon the Islamic concepts of knowledge and erudition. It stressed first and foremost the religious sciences, which included almost all the other forms of knowledge, from theodicy to pharmacology. Islam considers knowledge (*'ilm*) to be sacred, for, ultimately, all knowledge is related to one of God's theophanies. This notion of knowledge is still valid in the entire Islamic educational system, and it makes it inseparable from the institution of the *awqaf* (resources, foundations, or funds destined for education), which is supported by the religious organizations and institutions.[13] This conception has turned the traditional relationship between master and disciple into an intimate and spiritual bond. There is a famous saying attributed to 'Ali ibn Abi Talib: 'I have become the servant of him who instructed me (even if such instruction had been) a single word'. The substance of education has always been at the heart of Islamic culture, being one of its pillars.

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11 *Cf.* Beas, C., 'La transmisión de la ciencia antigua al mundo islámico según el Catálogo de an-Nadim', *o.c.*; and 'Las matemáticas y la astronomía en el mundo musulmán según el Catálogo de an-Nadim', *o.c.*

12 *Cf.* Bergstrasser, G., *Hunain Ibn Ishaq und seine Schule*, Leiden: Brill, 1913.

13 *Cf.* Makdisi, G., *o.c.*

As a consequence of this inseparable tie, the Islamic conception of knowledge is based on two basic principles: unity and hierarchy. As with existence itself (which is ultimately identical to knowledge), all the sciences or forms of knowledge are ultimately a single entity, yet at the same time, they conform to a hierarchical order.[14] The Islamic sciences and the intellectual perspectives cultivated in Islam have always been organised in a hierarchy that leads to the knowledge of the Unique, the supreme substance that is, from another viewpoint, the substance of all knowledge. For this reason, each time the Muslim intellectual authorities were confronted with sciences originally cultivated in other cultures, they sought to incorporate them into the Islamic perspective of the hierarchy of knowledge. For this same reason the philosophers and scientists of Islam were continually interested by the taxonomy of the sciences, from al-Kindi, al-Farabi and ibn Sina, to al-Ghazzali, Nasir ad-Din al-Tusi and Mulla Sadra.

Muslims considered two main channels open to men for the acquisition of formal knowledge: one of the revealed truth that, after its revelation, is passed on from one generation to the next in a way that Muslims called 'the transmitted sciences' (*al-'ulum al-naqliyya*); and the other of the knowledge acquired by the intelligence that God has granted to human beings, which was called 'intellectual sciences' (*al-'ulum al-'aqliyya*). To these two kinds of formal knowledge, altogether called 'acquired sciences' (*al-'ulum al-husuli*), we should add the wisdom that comes from seeing (*kashf*) and knowing (*dhawq*) the truth; this supreme form of knowledge has been called by Muslims 'witnessing knowledge' (*al-'ilm al-huduri*).

Given the wide prospect of pre-Islamic sciences that had become available through translations, and the vast river of knowledge that flowed from the ocean of the Koranic revelation, Muslim intellectual authorities undertook the classification of the sciences, trying to discover its hierarchy and to elucidate the existing harmony between reason and revelation, science and religion.

It was probably Al-Kindi who was the first to assume this task with his *Fi aqsam al-'ulum* (*On the Types of Skies*). However, it was his successor in the peripatetic school, Abu Nasr al-Farabi, who exerted a much greater influence over the curricula of Muslim universities and even over the curricula in the Latin West. Al-Farabi's *Kitab ihsa' al-'ulum* (*The Book of the Enumeration of the Sciences*) simultaneously shows, on the one hand, the

[14] *Cf.* Nasr, S.H., *Science and Civilization in Islam.*

Aristotelian classification of the sciences as it was transmitted to the Muslims through John Philoponus' comment on Porphyry's_*Isagoge* and, on the other hand, the will to reconcile this account with the one stemming from the Koran and the Law (*Shari'ah*). This work not only influenced successive Muslim authors, but it was also widely known in the Latin West due to Domingo Gundisalvo's_translation, which was quoted by various authors such as Pietro d'Abano.[15]

New forms of knowledge were born with the permanent development of the Islamic sciences. This was reflected in subsequent classifications, whose authors, such as ibn Sina, los Ikhwan as-Safa', al-Ghazzali, ibn Rushd, among others, dedicated a considerable part of their works to this task. The remarkable 8/14th century historian, ibn Khaldun, offers a complex classification of the sciences in his *Prolegomena* (*Muqaddimah*) to the general study of history.[16]

From the time of ibn Khaldun on, several philosophical and scientific encyclopaedias appeared in Arabic, Persian and Turkish in which the classification of the sciences was discussed. Some of these works, such as Qutb al-Din al-Shirazi's *Durrat at-Taj*, are mainly orientated towards philosophy, while others, such as Da'ud al-Antaki's *Thadhkirah*, are more directly related to the sciences. One of the most complete and widely-spread of such encyclopaedias, which mentions almost all the sciences cultivated in the Islamic world, is Shams al-Din al-Amuli's *Nafa'is al-Funun* (*Precious Elements of the Sciences*), written during the 9/15th century. Both the various sciences presented by Amuli and the classification on which his work is based show the range and hierarchy of the Islamic sciences after their full zenith, which was only achieved after centuries of development.

The 'physical' voice as it is understood today – that is, the one which designates a scientific discipline that mathematically describes the phenomena of movement – is of relatively recent use. Isaac Newton, who considered himself a naturalistic philosopher, in this way shared with the Muslim scientists a common way of seeing the world. Furthermore, Islamic sciences do not have a particular discipline that could be identified with physics in the modern sense. Natural philosophy (*tabi'iyyat*) included life, the natural sciences and physics; whilst other sciences such as optics were

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15 *Cf.* Dunlop, D.M., *o.c.*

16 *Cf.* al-Farabi, *Ihsha al-'ulum*, version by A. González Palencia, Madrid: CSIC, 1953; ibn Khaldun, *al Muqaddimah*, version by F. Rosenthal, New York: Pantheon Books, 1958. And also, Nasr, S.H., *Science and Civilization in Islam*.

classed by the Muslims among the mathematical sciences, even though nowadays we consider it to be part of physics.

II. Dimensions of ibn-Sina's Natural Philosophy (370-428 b.H./980-1037 AD)

In this section we will present the principles of natural philosophy as explained in the works of ibn Sina, who, among the Muslim doctors, dealt with the subject extendedly under the heading *fann as-sama' at-tabi'i* ('Section that deals with that which has been heard in relation to natural philosophy'). One has to bear in mind, however, that almost all the great Muslim philosophers and scientists devoted an important part of their work to this subject.

Natural philosophy (*tabi'iyyat*) is, according to ibn Sina, that aspect of wisdom that studies the realm of what moves and changes.[17] It is the study, qualitative and quantitative at the same time, of that what is an accident (*'arad*) and constitutes, together with mathematics and metaphysics, the realm of speculative philosophy. The areas of natural philosophy include all the sciences of the sub-lunar region. Geometry, astronomy, geography, geodesy, mechanics, statics, optics, and hydraulics, all disciplines that are nowadays considered part of physics, are classed as mathematics in ibn Sina's classification.[18]

Natural philosophy depends on certain principles, such as the notions of matter and form, time and space, and different kinds of movements, which are the basis of all natural sciences in the peripatetic sense. To ask why in the realm of natural philosophy is to search for the causes of something in terms of the Aristotelian four causes and in the context of the principles just mentioned.[19] As for proofs of the principles of natural philosophy, it is not possible to find them in their own domain, for the proofs of what is essential – such as the existence of a power called nature – can only be found in the domain of metaphysics. As ibn Sina claims, 'one cannot prove the principles of a science based only upon such science'.[20]

17 *Cf.* Ibn Sina, *'Uyun al-Hikmah*, ed. A. Badawi, Cairo: al-Mahad al-Ilmi al-Faransi lil-Athar al-Sharqiyah, 1954, p. 17; *cf.* Ibn Sina, *Fann-i sama'-i tabi'i*, ed. M. Furughi, Tehran: 1937, p. 12.

18 *Cf.* Ibn Sina, *Aqsam-i 'ulum-i aqliyah*, in: *Rahnameh-yi Hikmat*, Tehran: 1952, pp. 12-13.

19 *Cf.* Ibn Sina, *Tabi'iyat wa Ilahiyat*, in: *Kitab ash-Shifa'*, lithograph edition, Tehran: 1885-1887, pp. 33-34.

20 *Ibid.*, p. 41.

Before further analysing the meaning of the principles that underlie the study of natural philosophy, we must understand the meaning or meanings that ibn Sina gives to the term 'nature' (*tabi'ah*). The Aristotelians use the word 'nature' according to four meanings: *natura generatio*, *natura essentia*, *natura substantis simplex*, and *natura rei corporeae*.[21] Aristotle himself defines it as 'a beginning [principle, *arche*] and cause of the movement and rest by which something first begins-to-subsist as its own accord *(kath' hauto)* and not as a concomitant [*(kata symbebekos)*, accidentally]'.[22]

Ibn Sina also uses the term 'nature' in various senses, the most essential of these being the one that characterises it as the force responsible for the movement of the elements: 'the form of an element is a nature known by the action it produces, but not felt or seen through the senses'.[23] It is this nature which keeps the element in rest, provided that it is in its proper place, or moves it towards its proper position if it is out of its natural place.

Using the term 'nature' in a somewhat different sense, it can be said that the tendencies of lightness and heaviness are due to nature, which implies here the form of the elements, the form that gives them the particular qualities that they possess. Ibn Sina states, 'Thus, each of the four elements possesses a nature that corresponds to it and is its form (*surah*); fire has a nature of its own, and so do water, air, and earth. And these qualities are accidents that stem from such nature and such form'.[24] So, for example, the nature of water is that thanks to which it is water. If water is considered in relation to the movements and actions that it performs, it is studied from the perspective of its nature; if it is considered in relation to the substance from which its being stems, it is studied from the perspective of its form. When studying the relation that nature has with movement and rest, ibn Sina starts with the more general considerations to do with the subject of change. Every object in this world must be moved or changed either by an external force – as it happens with water when it is boiled – or by an internal force that belongs to its essence – as in the

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21 *Cf.* Ibn Gabirol, *Fons Vitae*, ed. C. Bäumker, Munster: Aschendorffsche Buchhandlung 1895, pp. 492-494.

22 *Aristotle's Metaphysics,* ed. W.D. Ross, 2 vols., Oxford: Clarendon Press, I924, II,1.

23 Ibn Sina, *Danesh Nameh. Tabi'iyat*, ed. S.M. Mishkat, Tehran: Danishgah-yi Tihran, 1952, p. 53.

24 *Ibid.*, p. 55.

transformation of a seed into a plant or of sperm into an animal. The force that produces the change can be classified as follows:

1. Simple Movement:
a) Involuntary – as the falling of a stone.
b) Voluntary – as the movement of the sun.
2. Complex Movement:
c) Involuntary – as the movement of plants.
d) Voluntary – as the movement of animals.

Ibn Sina defines nature according to the following classification: a) force (*quwwah*); b) celestial soul (*an-nafs al-falakiyah*); c) vegetative soul (*an-nafs an-nabatiyah*); and d) animal soul (*an-nafs al-hayawaniyah*).[25] Thus, in this perspective nature becomes, in combination with the different souls, one of the responsible forces in the universe. However, it is also the power that keeps something at rest. Its function is not only dynamic but also regulatory; it is not only a power that should stem from the essence of something else and produce all qualitative and quantitative changes; it is also the power that keeps an object at rest, making it remain what it is.

Aware of the various uses of the term 'nature', Ibn Sina writes: 'We shall mention, first, three meanings of this word: 1. Nature as form of the simple elements. 2. Nature as that from which the substance of something is formed. 3. Nature as the essence of things'.[26] He adds to this list the meaning of nature as the power that preserves the cosmic order. Nature can be considered as particular (*juz'i*) or universal (*kulli*). Particular nature is confined to each individual; universal nature can be considered as a part of the intelligible order, being the immaterial source from which the total order is derived.[27]

The study of time and space, matter and form, as the primary conditions of earthly existence has to be approached bearing these different meanings of the philosophical term 'nature' in mind, as well as both the purpose and goal of natural philosophy. The final goal of this study is to understand movement, which in medieval thought always means change in terms of principles that belong to a realm that in itself is beyond change –

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25 *Cf.* Ibn Sina, *Tabi'iyat wa Ilahiyat*, in: *Kitab ash-Shifa'*, p. 12; *cf.* Ibn Sina, *Fann-i sama'-i tabi'i*, pp. 39-40.

26 Ibn Sina, *Fann-i sama'-i tabi'i*, p. 48.

27 *Cf. ibid.*, p. 52. One can notice here that even when Ibn Sina presents the Peripatetic theory, he does not remain within its limits.

whilst also bearing in mind that the principles of the sciences of nature in the Islamic world are not in these sciences themselves but in metaphysics (*ilahiyat*).

The basic intuition of hylomorphism, which underlies the Aristotelian doctrines, hovers into medieval philosophy, even though the meanings given to form and matter are not always the ones assigned by Aristotle. This is also the case in ibn Sina's account. According to him, 'form is the quality of *quidditas* (*mahiyah*) by which a body (*jism*) is what it is, while matter is that what supports (*hamil*) the quality or form'.[28] Matter can only exist thanks to the form given to it by the intellect; without form, it would be mere receptivity lacking reality. This is why the first matter cannot be found in itself. Furthermore, 'matter is created for form, and its purpose is to posses a form that is imposed upon it; in contrast, form is not created for matter'.[29]

Body (*jism*), which is constituted both by matter and form, is that which has the disposition of being divided. In so far as it possesses a bodily form, it is in actuality; in so far as it is capable of receiving it, it is in potency.[30] A body can be considered as a substance that possesses, on the one hand, actuality, and on the other, potentiality. The former is its form; the latter, its matter. The complex notion of matter in ibn Sina springs from various sources, both Aristotelian and Neo-Platonist. According to Aristotle, generation and corruption mean a transition from existence in potency into existence in actuality, and vice versa; it does not mean, then, a transition from not-being into matter. For him, matter exists in potency, which means that it already possesses a way of being. In a substance, the form is actual and the matter is potential, both being inseparably united in all things that are not pure actuality. Matter clearly has two different meanings for him, one as *hylé*, which is that which is in potency; the other one as *to hypocheimenon*, which is the substrate that persists permanently through generation and corruption.

The term *hylé* is also used by Neo-Platonists, but with the meaning of not-being – *to me hon*. *Hylé* does not have an existence in potency for them,

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[28] *Ibid.*, p. 46.

[29] Ibn Sina, *Tabi'iyat wa Ilahiyat*, in: *Kitab ash-Shifa'*, p. 33; *cf.* Ibn Sina, *Fann-i sama'-i tabi'i*, p. 96.

[30] *Cf.* De Boer, T.J., *o.c.*, p. 139.

as it has for Aristotle; it does not have existence at all. Therefore, there is no material cause, nor creation out of matter, for it does not even exist.[31]

Ibn Sina rejects the Aristotelian idea of existence in potency and admits only existence in actuality. His distinction between impossibility, contingency and necessity opposes the Aristotelian distinction between potentiality and actuality. Thus, while for the Peripatetics matter is eternal and *hylé* does not admit or require a cause (for it is necessary), according to ibn Sina *hylé* needs multiple causes to exist in actuality. Matter is driven into existence by the form that is granted to it by the intelligence of the tenth sphere which rules the sub-lunar region. In his doctrine of matter, ibn Sina implicitly assumes the original matter of the Ikhwan as-Safa', but without mentioning it. Considering *hylé* as the substrate of corporeality, it is that to which corporeal form (*surah jismiyah*) is added so that a general body can exist. The body is the sum of corporeal form plus matter.

Matter is also the individuation principle, that which enables a multiplicity of forms.[32] However, matter by itself has only a negative existence, and the capability (*qabiliyah*) of accepting division, upon which the form of corporeality is imposed. Matter is deprived of all perfection due to its inexistence or, which is equivalent, due to its inherently farthest position from the Being, which is the source of all perfection. Matter is, thus, pure passivity; it does not do anything by itself, remaining always as the substrate upon which the celestial forces will act. The influence of the intelligences is what prepares matter to receive form, imposing upon it, afterwards, various forms, the form of matter being its reason for existence. In contrast with Aristotle, for whom form and matter have their own reality, ibn Sina emphasizes the ontological disparity between them. According to him, form is the principle of matter or what links it with being; without form, matter does not exist.

Through metaphysical, logical, and experimental arguments, Ibn Sina rejects the different forms of atomism presented by an-Nazzam, ash-Shahrastani, and other theologians and philosophers, as well as their corollary – the existence of vacuum.[33] He presents Aristotle's arguments against vacuum, such as the example whereby a body that should posses a limited speed in water or in air may have an unlimited speed in vacuum. He

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31 *Cf.* Duhem, P., *Le système du monde. Histoire des doctrines cosmologiques de Platon à Copernic*, 10 vols., Paris: Hermann, 1913-1959, vol. IV, pp. 454ss.

32 *Cf.* Goichon, A.M., La philosophie d'Avicenne et son influence en Europe médiévale, p. 47; ibn Sina, *Kitab al-Isharat wal-Tanbihat*, version by A.M. Goichon, Paris: Vrin, 1951, p. 271.

33 *Cf.* Ibn Sina, *'Uyun al-Hikmah*, pp. 24-25.

also offers as experimental evidence the case of the inverted jar that does not lose its water, as well as the case of the suction plates that cannot be separated. He argues that the cause for both phenomena is that nature does not allow the creation of vacuum.[34]

While discussing the composition of the bodies, ibn Sina rejects the accounts advanced by the ancient atomists like an-Nazzam, who considers that it is possible to divide a body indefinitely. He discusses the problems of an indefinite division posed by Zeno by opposing them with responses based on Aristotle, and he criticises Democritus, who believed that bodies are constituted of corporeal indivisible particles.

One of his arguments against atomism states that everything that occupies a space can be divided due to the fact that all space has a beginning, a middle, and an end, thus being able itself to be divided. He also offers some geometric arguments similar to the ones used in his discussion with al-Biruni. For example, ibn Sina claims that if the existence of an atom is to be accepted and this atom can be placed between two additional atoms, either it must touch them in two different parts, in which case it would no longer be geometrically indivisible; or, it must touch them everywhere, and then there would be no possible distinction among them. Or, a third possibility, it could not touch the other atoms at all, and then it would no longer be acceptable to state that a body is constituted by atoms. Since the three possibilities exclude themselves, the existence of atoms must be rejected. The atomist could respond that the movement proceeds by instant leaps; however, this would be also difficult to accept as, according to this argument, a square formed by regularly placed points would have a diagonal equal to its side, for the diagonal and the sides would have the same number of points.[35]

Ibn Sina's opinion in relation to this complex issue leads him to the acceptance of the division of a body at any point regardless of how far this division could be undertaken; i.e. he assumes that a body is indefinitely divisible in potency, but not in actuality. Even if a body could be indefinitely divisible in potency, the process of division is not infinite.[36] In fact, all bodies are constituted of form and matter, the corporeal form being, in its essence, continuity (*ittisal*); matter, on the other hand, possesses the

[34] *Cf.* Ibn Sina, *Kitab al-Isharat wal-Tanbihat*, p. 275.

[35] *Cf.* Ibn Sina, *Danesh Nameh. Tabi'iyat*, pp. 77-81.

[36] The resultant difficulties in applying numbers of pure quantity to the physical domain are an indication that space is not a pure quantity, for it possesses a qualitative nature that cannot be denied.

disposition to accept both continuity and division or discontinuity (*infisal*), these two features – essential discontinuity and the possibility of division – being characteristic of all corporeal objects.

All bodies, besides consisting of form and matter, exist in the corporeal state due to time and space. For the Peripatetic natural philosophy, the core of the problem of movement – that is, the parameters of time and space in terms of which it is possible to describe movement – is of the highest importance. However, time and space are never considered independently from the bodies, but rather taken as two conditions of corporeal manifestation. As far as this is concerned, the equivalence established during the 17th century between geometrical space and the physical space in which the bodies are placed, radically distinguishes modern physics from the conception being analyzed here. For ibn Sina, the idea of space and time existing independently from the bodies is absurd. There is no space if there is no corporeal existence, for space is a condition of this state of manifestation and not an independent reality.

Ibn Sina emphasizes that the body exists prior to geometric space: 'You know that the body is prior to the surface in terms of existence, the surface prior to the line, and the line to the point; this has been proved by the researchers. As for the inverse formulation – that the point produces a line with its movement, the line a surface, and the surface a body – it corresponds to a way of speaking that is ideal for making understood, for conceiving and imagining'.[37] The notion of space is closely related to the natural place of things in the universe. Each simple element possesses its natural place.[38] Under this theory, the place of a body is identified by the limits that surround it; for example, the place of fire is within sky, and the place of air within fire. In the case of water, which is placed in a container, it is surrounded by the surfaces of the jar that contains it, jar that is, hence, its place (*makan*). The place of an object, or that which presents itself to us as the space that surrounds it, is consequently not more than the limit of that which contains the object.

The notion of space is closely related to the notions of direction and orientation. Hierarchy implies direction and orientation. Since medieval science is based on the idea of hierarchy, the meaning of direction is fundamental. In the works of ibn Sina that are considered here, the aspects of spatial symbolism are not explicitly considered; however, the meaning

[37] Ibn Sina, *Kitab al-Isharat wal-Tanbihat*, p. 273.
[38] *Cf. ibid.*, pp. 283-284.

conferred to the notions of up and down, and to the hierarchy derived from it, is affirmed as absolute and independent from any subjective relativity.[39]

Ibn Sina relates the six directions of space with the directions of the human body: right and left, previous and subsequent, and up and down. The first four are relative, while the last two are absolute, corresponding to sky and earth. Since an absolute direction cannot be determined by bodies in rectilinear movement, it is determined by the celestial spheres. The centre of the sphere of the cosmos is directed downwards; and its circumference, upwards. Furthermore, the skies have an East-West direction that corresponds to the places of rise and set of the stars; a vertical direction that corresponds to the place of the sun at noon and to the horizon of the earth; a forward and a backward directions that corresponds to the direction of the movement of the skies (*aflak*) and to its opposite; and finally, a direction towards the right and the left, East being the right and West the left. Due to this correspondence, the skies are like a living creature oriented towards the North Pole.[40]

Thanks to this differentiation of space, the world has the three basic dimensions: length, width, and depth. Length is the plane between the two poles; width is the plane between right and left; and depth the one between what lies in front and what lies behind.

Curiously enough, the South Pole is placed in the ascending direction and the North Pole in the descending direction, for, according to ibn Sina, 'if someone lies on his back looking at the skies, and with his right hand towards the East, his head will be oriented towards the South'.[41] Therefore, it can be understood that both direction and orientation depend on the skies, and have only a nominal existence if considered in relation to the world of the elements. The infinity of space can be crystallised into its basic directions only in relation to the skies, which provide space with a qualitative aspect of core significance.

Time possesses a nature that is more qualitative than space, and cannot be defined or measured as easily. Whereas space can be measured through a chosen unit of measurement, human beings do not have a faculty with which to measure time in the same direct way. The measuring of time depends on movement. Ibn Sina defines time (*zaman*) as the

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39 *Cf. ibid.*, pp. 275-277.

40 *Cf.* Ibn Sina, *Fann-i sama'-i tabi'i*, p. 325. The analogy in the spatial orientation of the cosmos and the micro-cosmos is evident (*al 'alam al-Kabiru wa al-'alam as-saghiru*, respectively).

41 *Ibid.*, pp. 325-326.

quantity or measurement of movement. Hence time depends completely on change: 'if there is no change or movement, there is no time'.[42] Just as bodies do not exist in a uniform space, and space is a condition of corporeality, movement does not occur in a uniform time, for time is one of the characteristics of movement, which, in its more general sense, means change. If there was no birth and extinction of beings, there would be no before or after.

Time is a continuous quantity that can be indefinitely divided without ever reaching 'an atom of time'.[43] The proof of its existence lies in the observation of two bodies that, departing from the same point, do not reach earth together but one after the other. Such proof of the existence of time depends on the continuity of movement and implies, indirectly, the continuity of time. As it is continuous, time, like space, can be subjected to division (*fasl*), and its limit is the moment (*an*). A moment does not possess an actuality – as in the theory proposed by the Ash'aritas, who believe in the 'atom of time'– but rather exists only potentially (*bi-l-quwwah*) and imaginatively (*bi'il-tawahhum*).

A point in space can be understood as the indivisible part of a line, or as the geometric entity that, with its movement, produces a line. A moment in time can also be conceived of in two ways: as the instant that is part of time and whose existence depends on time, or as the instant whose movement produces time. For ibn Sina the point in space, like the temporal moment, has only an imaginary (*tawahhumi*), not real (*haqiqi*), existence. However, the unreality of the moment does not compromise the reality of time, which depends on both the universal soul and the circular movement of the skies. If there was no celestial rotation, there would be no time and no directions in space, or any kind of movement. Thus, space and time are defined by the skies, and allow the existence of rectilinear movement in the sub-lunar region.[44]

The question of movement becomes significant in natural philosophy once nature is no longer conceived of as a living principle; that is, when an irreducible distinction between living things and inert matter has been established. The question of how the living creatures move never comes to ~~the~~ mind in the same way as it does when we consider bodies without any innate movement. For this reason, the problem of movement is central in Aristotelian physics, as the living universe of ancient times is utterly no

42 *Ibid.*, p. 204.

43 Ibn Sina, *Danesh Nameh. Ilahiyat*, ed. Mo'in, Tehran: 1952, p. 128.

44 *Cf.* Ibn Sina, *Fann-i sama'-i tabi'i*, pp. 214-217.

longer considered as such. The vulnerable aspect of peripatetic natural philosophy lies precisely in this area, which will become the focal point of the attacks that will destroy the structure of medieval physics.

Contrastingly, in a contemplative account of nature there is no radical distinction between what is dead and what is alive. All natural phenomena and all terrestrial beings are symbols of the spiritual world, becoming more central as they ascend in the ontological hierarchy. The problem of movement, in this context, becomes peripheral. This is why the topic is seen as relatively unimportant in the works of ibn Sina which deal with a spiritual vision of the world. On the other hand, however, it is a major topic in his peripatetic writings. This approach includes both qualitative and theological aspects of change, and takes into account movement as change of place.

According to ibn Sina, who follows Aristotle's reasoning here, movement is 'the transition in time from potentiality to actuality in a continued way or in a non-immediate way'.[45] When an object lies between potentiality and actuality, it is in movement. Movement should also be considered as the first entelechy (*kamal*) of that which is in potentiality, and the gradual actualization, dependent on time, of that which is in potentiality. An object moves because there is something in it which is still potency and is, therefore, imperfect: in this way, it will look for its perfection as part of the total purpose of the universe. Movement not only depends on the mover and the moved, on time and space, but also on an origin and an ending. Any discussion on change that does not examine teleology does not consider all the factors involved.

There are three kinds of movement:

Accidental – (*bi'l-arab*)
Violent – (*bi'l-qasr*)
Natural – (*bi'l-tab'*)

Accidental movement takes place when a body lies within another body that is in movement. Violent movement is not caused by the essence of the body that is moved, but by an external force, for example when an object is thrown or burnt. The natural movement springs from the object itself, for example when air and fire rise. The distinction between natural and violent movement depends on the distinction between the movement of

[45] *Ibid.*, p. 102. To my mind, the clearest introduction to Aristotle's natural philosophy can be found in Lindberg, D., *The Beginnings of Western Science*, Chicago: University of Chicago Press, 1992.

the skies, which is circular, and the sub-lunar movement, which is rectilinear.[46]

Ibn Sina uses yet another classification of movement or change that is wider than the one inspired by dynamics. It includes four kinds of movement: growth, decrease, compression, and expansion. He also considers the problems posed by the movement of projectiles, which, from the time of John Philoponus (6th century), had been paramount to Aristotelian physics. The solution proposed by ibn Sina claims that a moving body receives (*istifadah*) an inclination (*mail*) from the entity that moves it which enables it to continue its movement. The inclination transmits all the force that keeps the body in movement, but it differs from the propelling force (*quwwah muharrikah*), which still exists even though the movement has stopped. The inclination provides force to the movement until the resistance of the environment exhausts it.

Ibn Sina attempted to establish a qualitative relationship for this form of movement and claimed that a body moved by a given force would have a speed inversely proportional to its 'natural inclination' (or weight), and that the distance travelled by a body that moves at a constant speed is directly proportional to its weight. This theory, refined by Abu-l Barakat al-Baghdadi, influenced subsequent Muslim thinkers.

Ibn Sina's theory was adopted by al-Bitruji before entering the Latin world and being translated as *inclinatio violenta* (*mail qasri*). The name was changed to *impetus impressus* by John Buridan (14th century), and was defined as the product of mass and speed, which is equivalent to the notion of linear momentum in modern physics. Galileo's *impeto*, the term with which he named this momentum, was no other than the concept elaborated by John Philoponus and ibn Sina, although at that stage it did not have the connotation that it used to have among medieval writers. While medieval scientists conceived of the *impetus* as the efficient cause of movement, it became for Galileo a way to describe movement in mathematical terms, thus enabling a new kind of physics: modern physics.[47]

Three kinds of *mail* are distinguished by Ibn Sina: *mail nafsani*, *mail tabi'i*, and *mail qasri* (psychic, natural, and violent respectively). This distinction, as well as the term 'mail' itself, which also means desire, implies that the study of movement does not involve only inert things. By identifying this *inclinatio* with the omnipresent love in the universe, ibn

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[46] *Cf.* Ibn Sina, *Fann-i sama'-i tabi'i*, pp. 401-402.

[47] *Cf.* Duhem, P., *o.c.*; Moody, E., *Studies in Medieval Philosophy, Science and Logic*, Los Angeles: University of California Press, 1975.

Sina returns to the account of a living world, one in which all movement stems from the sympathy among beings and the love of the universe, which is ultimately directed towards God.[48]

(Translated from Spanish by Michell Nicholson)

[48] *Cf.* Ibn Sina, *Danesh Nameh. Ilahiyat*, p. 145.