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ABSTRACT

Ibn Sīnā, or Avicenna as he was known in the Latin West, is one of the most influential thinkers both in the Muslim world and in medieval Europe. This article examines some aspects of his thought on science, its logic and epistemology as well as its hierarchy and methodology. It is argued that Ibn Sīnā's philosophy of science is a kind of synthesis that draws upon many sources, mainly Aristotelianism and Neoplatonism. A major part of his contribution, however, lies in putting the pieces together in a manner quite different from his precursors, and in offering new arguments to clarify and justify his positions.

Keywords: Ibn Sīnā, Avicenna, philosophy of science, scientific knowledge, aim of science, induction

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Philosophers of science think deeply, carefully, and critically about science. Defined as an attempt to understand the nature, aims, and methods of science, philosophy of science examines what scientists do, what it means for an explanation to be scientific, how scientific claims are justified, the sort of logic underlying scientific research, and other related issues.[1] While the name is relatively modern, such a reflection has been around for centuries, going back to Aristotle, who was probably the first thinker to identify problems and puzzles concerning science and sought to solve them.[2] The discussion continued in medieval times in which Ibn Sīnā was one of the important participants. Given his reputation as a philosopher-scientist, it is rather surprising that Ibn Sīnā's contribution to philosophy of science remains hitherto underexposed as compared to his views on metaphysics and medicine, notwithstanding pioneering articles by Hossein Nasr,[3] Dimitri Gutas,[4] and Jon McGinnis.[5] This article explores some aspects of Ibn Sīnā's thought on the logic, epistemology, hierarchy and method of science.

I. POSSIBILITY AND VARIETY OF SCIENTIFIC CLAIMS

In contrast to philosophers like Descartes who tried to demolish everything completely and start right from the foundations, Ibn Sīnā agrees with Aristotle that all learning and research and all teaching of the discursive sort begin with preexistent knowledge.[6] He affirms, against the pretensions of reason, the fact that human knowledge does not come about from

1 This paper was presented at the Avicenna Conference, Brigham Young University (BYU) Utah, in June 2010. The author is grateful to the wonderful host, the scholarly audience and the generous sponsor for covering the cost of travel and accommodation during the conference.

2 See, for example, Bas C. van Fraassen, "A Re-examination of Aristotle's Philosophy of Science," *Dialogue* 19 (1980), 20-45.

3 Seyyed Hossein Nasr, "The Achievements of Ibn Sīnā in the Field of Science and his Contributions to Its Philosophy", in *Islam & Science*, vol. 1 (2003), 235-44.

4 Dimitri Gutas, "Medical Theory and Scientific Method in the Age of Avicenna," in *Before and After Avicenna,* ed. David C. Reisman and Ahmed H. al-Rahim (Leiden: Brill, 2003), 145-62.

5 Jon McGinnis, "Avicenna's Naturalized Epistemology and Scientific Method," in *The Unity of Science in Arabic Tradition: Science, Logic, Epistemology and their Interactions,* ed. Shahid Rahman *et al.* (Dordrecht: Springer, 2008), 129-52.

6 Ibn Sīnā, kitāb al-Burhān, ed. Abu al-ʿAlāʾ ʿAfīfī (Cairo, 1956), 57: "kullu taʿlīm wa taʿallum dhihnī fa-bi-ʿilm qad sabaq" and ibid., 72: "kullu maṭlab min hādhihi innamā yutawaṣṣal ilā naylihi bi-umūr mawjūdah ḥāṣilah." Cf. Aristotle, Posterior Analytics 1.1.71a 1-2 = Manṭiq Arisṭū, ed. ʿAbd al-Raḥmān Badawī, 3 vols. (Kuwayt and Beirut: Wakālat al-Maṭbūʿāt / Dār al-Qalam, 1980) 2:329: "kullu taʿlīm wa kullu taʿallum dhihnī innamā yakūnu min maʿrifatin mutaqaddimat al-wujūd."

scratch– an epistemological stance reflecting the ontological principle which he upholds: *ex nihilo nihil fit* –that is, nothing comes out of nothing. Historically, this view was put forth as a solution to the paradox of learning and the impossibility of acquiring knowledge –or science, for that matter, first stated by Plato in one of his dialogues (*Meno* 80D-E) and later recast by Aristotle. If learning is to know or discover something that is unknown to us, then it is impossible. For, how can we learn anything about something if we know not what it is that we want to learn? Yet if we already know what it is, then there is no such thing as learning, for we do not really learn or know anything about it except what we already know, so goes the argument.[7]

It was to resolve this paradox that Plato introduced his famous theory of *anamnêsis* which says that learning is nothing but recollection or retrieval of innate foreknowledge. His disciple Aristotle tried to solve the problem by drawing a distinction between particular and universal knowledge. Learning, according to him, proceeds from particulars to universals (*apò tôn kath hekasta èpì tà katholou*), and hence is both empirical and rational. There is nothing in the mind that was not first in the senses. All knowledge begins with sensory perception *(aisthêsis)* and experience *(empeirea),* which provide the basic necessary data, about particulars, then followed by abstraction (*apharêsis*) and induction (*epagôgê*) which result in the formation of generic concepts (*tò katholou*) and universal knowledge.[8]

The so-called paradox of learning reappears in Ibn Sīnā's kitāb *al-Burhān*, a section of the logical part of his kitāb *al-Shifāʾ*.[9] His solution to the problem is quite interesting: If what we want to know or learn about is already known to us in all respects, then there is no need for learning. Similarly, if our scientific quest is for something unknown to us, then it will be futile. However, the fact is that the object of our inquiry is neither already known completely nor is it totally unknown to us. Rather, the thing is known in two respects only and yet still unknown to us in another respect. For we do have an idea about it –that is, we know what it is conceptually already, just as we potentially have some belief about it (i.e. that it is such-and-such). So the remaining aspect that we have yet to learn and investigate is 'why' it is so and

7 Aristotle, Posterior Analytics 67a21-25 = Manṭiq Arisṭū, 2:331: "*immā an lā yakūna ʾl-insān yaʿlamu shayʾan, wa immā an yakūna innamā yataʿallamu ʾl-ashyāʾ allatī yaʿlamuhā*", Ibn Sīnā, *Kitāb al-Burhān*, 74-75 ("*immā an yakūna ṭāliban limā yaʿlamuhu fa-yakūnu ṭalabuhu bāṭilan, wa immā an yakūna ṭāliban limā yajhaluhu, fa-kayfa yaʿlamuhu idhā aṣābahu?*").

8 See Aristotle, *Posterior Analytics,* II.xiii 97b and II.xix 99b-100b. "On abstraction", see his *De Anima* 429b.

9 Ibn Sīnā, *al-Shifāʾ: al-Manṭiq: al-Burhān*, 74: "*al-ṭālib ʿilman mā immā an yakūn ṭāliban limā yaʿlamuhu fa-yakūn ṭalabuhu bāṭilan, wa immā an yakūn ṭāliban limā yajhaluhu, fa-kayfa yaʿlamuhu idhā aṣābahu?*".

so and such and such specifically.[10] As for the next question–i.e. 'How is knowledge possible?' Ibn Sīnā's reply would be thus: knowledge begins with simple, primitive concepts and basic principles that the mind knows and understands without prior learning.[11] It is this a priori knowledge (*awwaliyyāt* or *badīhiyyāt*) that allows human beings to make a belief-statement or knowledge-claim.

It should be noted that since every claim of knowledge is mirroring a belief about some fact, event or phenomenon–natural or otherwise, each belief is therefore a stab at the truth. Now when such belief is expressed in the form of statement, proposition (epistemic or scientific claim), Ibn Sīnā calls it *taṣdīq*–literally 'affirmation', rendering the Aristotelian term *apophansis* but often inaccurately translated as 'judgement'.[12] Indeed, in communicating what they know and in stating what they believe, human beings (scientists, scholars, etc.) use words, which make up sentences, and sentences argument. Words signify concepts formed by definition, whereas sentences, or propositions, express beliefs that are supposed to represent the truth about the world and from which –in the form of argument– one can deduce other truths about reality.

Thus, science is, for Ibn Sīnā, a structured body of knowledge composed of and analyzable into concepts, premisses, and arguments. On this he concurs with Aristotle, whom he calls the First Teacher (*al-muʿallim al-awwal*)[13]–the second being al-Fārābī (d. 950), that science is at best when its method of proof is deductive (i.e. syllogistic), whereby certain things being stated, something other than what is posited follows of necessity from their being so.'[14]

The model of science Ibn Sīnā advocates is therefore mathematical, probably because he considers mathematics to be the farthest away from error, while other sciences are not.[15] Hence the example he gives us: the fact that the three internal angles of a triangle added up to two right angles could be demonstrated to follow necessarily from the definition of a triangle.[16] One might wonder whether Ibn Sīnā actually follows the model he espouses in his own scientific works. The answer turns out to be negative, however. While this model suits the mathematical sciences like geometry and astronomy, it is difficult to apply in other branches of science like biology or psychology. Ibn Sīnā himself in the Physics part of *kitāb al-Shifāʾ* mostly presents a philosophical analysis of descriptions of nature, motion, time, place, atoms etc. and of the assumptions underlying those descriptions, employing methods that are rarely based on demonstrative syllogism, let alone direct empirical studies such as experimentation, measurement or observation other than those of ordinary everyday experience.

Given the fact that different people may lay different claims of knowledge about the world, Ibn Sīnā distinguishes various types of belief-statement that scientists may and may not use for their purposes. In the opening section of *kitāb al-Burhān* he divides epistemic claims into four classes, indicating the varying degrees of certainty assigned to each category in terms of being 'most certain', 'almost certain', 'less certain', 'more or less certain' and 'not certain all':

1. The first and highest class of epistemic claim is the most certainly true (*yaqīnī*) and the least dubious one. It reflects a twofold belief (*iʿtiqād*) of someone who (i) believes that *p* (where *p* is any categorical proposition–that it is true that *p*; that *p* is truly the case) and (ii) believes, whether actually or almost actually, that *p* cannot be otherwise (i.e. that not-*p* is impossible) if the belief that *p* is to be held.[17] According to Ibn Sīnā, however, only the so-called 'primary cognitions' (*awwaliyyāt*) belong to this category, such as our knowledge that the whole is greater than its part, the truth of which is assented to by the mind *a priori*, neither by means of sensory perception nor induction since it is part of our innate cognition (*min jibillatihi*).[18] It is called 'primary' owing to the fact that it has existed from the beginning of human intellection (*fī awwal al-ʿaql*).[19] Arguments and proofs constructed with premises of this sort are called demonstrative (*burhānī*), which Ibn Sīnā considers as the most rigorous and therefore should be the standard for scientific proof.[20]

2. The second type of epistemic claim is one which is almost certainly true (*shabīh bi 'l-yaqīn*). This is the case when you believe that *p,* without denying –whether actually or almost actually- that *p* may be otherwise. In fact, says Ibn Sīnā, the first belief (that *p*) would

10 Ibn Sīnā, al-Shifāʾ: *al-Manṭiq: al-Burhān*, 75: "*inna al-maṭlūb law kāna maʿlūman lanā min kull jihahmā kunnā naṭlubuhu, wa law kāna majhūlan lanā min kull jihah mā kunnā naṭlubuhu. Fa-huwa maʿlūm lanā min wajhayn majhūl min wajh, fa-huwa maʿlūm lanā bi al-taṣawwur bi al-fiʿl wa maʿlūm lanā bi al-taṣdīq bi al-qwwah. Wa innamā huwa majhūl lanā min ḥaythu huwa makhṣūṣ bi al-fiʿl.*".

11 Ibn Sīnā, *al-Shifāʾ: al-Manṭiq: al-Burhān*, 77: "*fa-yajibu an takūn ʿindanā mabādiʾ ūlā li al-taṣawwur wa mabādiʾ ūlā li al-taṣdīq. … bal lā muḥālata an yakūn ʿindanā umūr muṣaddaq bihā bilā wāsiṭah wa umūr mutaṣawwarah bilā wāsiṭah.*"

12 Cf. H.A. Wolfson, "The Terms *taṣawwur* and *taṣdīq* in Arabic Philosophy and Their Greek, Latin and Hebrew Equivalents," in *Studies in the History and Philosophy of Religion*, ed. I. Twersky G.H. Williams (Cambridge, MA: Harvard University Press, 1973), 1: 478-92.

13 Ibn Sīnā, *al-Shifāʾ: al-Manṭiq: al-Burhān*, 54 (line 7).

14 See *Mantiq Aristū*, 1: 142 = *Prior Analytics* I.I, 24b 18-20; Ibn Sīnā, *kitāb al-Najāt*, ed. Mājid Fakhrī (Beirut: Dār al-Āfāq al-Jadīdah, 1985), 69.

15 Ibn Sīnā, *al-Shifāʾ: al-Manṭiq: al-Burhān*, 196 (lines 2-3).

16 Ibid.

17 Ibid, 51 (lines 8-10).

18 Ibn Sīnā, *kitāb al-Najāt*, 101.

19 Ibid, 105.

20 Ibn Sīnā, *al-Shifāʾ: al-Manṭiq: al-Burhān*, 51 (lines 16-17).

disappear as soon as the second belief (that not-*p*) is confirmed. Included among this kind are epistemic claims derived from sensory perception (*maḥsūsāt*), observation (*mushāhadāt*), experimental data (*mujarrabāt*), facts established by traditions (*mutawātirāt*), intuitive cognitions (*ḥadsiyyāt*), and mathematical postulates 'whose syllogism is found with them' (*muqaddamāt qiyāsātuhā maʿahā*). Arguments or proofs made up of any of these are also regarded as 'demonstrative' (*burhānī*).[21]

3. To the third category belongs that which is less certainly true because it merely aims at convincing people and persuading them (*iqnāʿī*), regardless of its truth value. One's claim of knowledge is so regarded if he believes that *p,* while at the same time –whether actually or almost actually– believes that not-*p* is also possible, even though he might not be committed to the second belief.[22] What belong to this category are cognitive claims that represent popular myths or legends (*mashhūrāt*), mental images and fiction (*wahmiyyāt*), taken-for-granted views (*musallamāt*) which are assumed to be true for the purposes of disputation or debate only. Arguments or proofs composed of this kind of epistemic claims are called 'dialectical' (*jadalī*) and 'sophistical' (*sūfisṭīqī mughālaṭī*).[23]

4. The fourth class comprises knowledge-claims that are more-or-less certain, possibly true and possibly false, being based on conjectures (*ẓannī*). This is the case when one holds *p* without at the same time –whether actually or almost actually– denying the possibility of not-*p*, and yet his mind is inclined more towards the first belief (that *p*) rather than the second one (that not-*p*).[24] Of this sort are epistemic claims that represent well-received or commonly accepted opinions (*maqbūlāt*) and claims based upon guesswork and conjectures (*maẓnūnāt*). Arguments or proofs using this type of claims are dubbed 'rhetorical' (*khiṭābī*).[25]

5. Finally, there is a fifth kind: that which is not certain and unworthy of credence at all (*lā yūqiʿu taṣdīqan*) as it merely tries to provoke people's imagination and manipulate their feelings (*yūqiʿu takhayyulan muḥarrikan*). The question of veracity becomes irrelevant in this case since the person does not make any determinate judgment so that no truth-value can be assigned to his claim. Ibn Sīnā calls this type of provocative utterances *'mukhayyalāt'* and the argument made up of them 'poetical' (*shiʿrī*).[26]

21 Ibid, 51 (line 17).
22 Ibid, 51 (lines 14-16) and 63-67.
23 Ibid, 63-7.
24 Ibid.
25 Ibid.
26 Ibid.

The reason why Ibn Sīnā delineates these different kinds of epistemic claims and forms of reasoning seems to be that he wanted to provide a secure foundation for science, which he understood to be a coherent system of statements purporting to mirror the reality it explains. Science should consist of a set of explanatory deductions–namely, a chain of demonstrative syllogisms, preferably in the universal mood ("All *B*s are *C*s, all *A*s are *B*s, so all *A*s are *C*s"), where each of the premises –and hence the conclusion– will be a necessary truth. According to this model, scientists start their research from basic concepts or definitions as well as from 'first principles' (*mabādiʾ awwaliyyah*) that are self-evident and known with absolute certainty, then move on to deduce other propositions (hypotheses, theories) from those already known as certain in such a way that the logical validity of the inferences guarantees the same degree of certainty for the conclusions drawn as was available for the initial premises. The certainty Ibn Sīnā requires from science is twofold: one is in the knowable things, which are necessary as such; the other is in the mind of the scientist, who must be absolutely sure that things cannot be otherwise. The certainty involved is therefore both objective, with respect to the objects known, and subjective, with respect to the knowing subject.[27]

27 Ibn Sīnā, *al-Shifāʾ; al-Manṭiq; al-Burhān*, 78: "*fa al-ʿilm alladhī huwa bi al-ḥaqīqah yaqīn huwa alladhīyaʿtaqidu/yuʿtaqadu fīhi anna kadhā kadhā, wa yaʿtaqidu/yuʿtaqadu annahu lā yumkinu an lā yakūna kadhā iʿtiqādan lā yumkinu an yazūl.*" Cf. Jon McGinnis, "Avicenna's Naturalized Epistemology and Scientific Method," 131-2: "Throughout *kitāb al-Burhān* Avicenna uses 'certainty' in two conceptually distinct ways. Thus, sometimes 'certainty' refers to one's assurance or knowledge of some natural necessity, and in this sense 'certainty' seems to be relative to the knower and the justification and warrant one has for a belief. More frequently, however, 'certainty' refers to the necessity or inevitableness of some causal relation in the world, which, though captured in the premises and conclusions of a demonstration, nonetheless is independent of any knower and his syllogizing, and in fact provides the very basis for knowledge and syllogisms." Referring to Ibn Sīnā's *kitāb al-Burhān* I.7, 31.11–18 (ed. ʿA. Badawī); 78.15–79.4 (ed. ʿAfifī), McGinnis (p. 148, note 7) adds: "It is interesting to note that Avicenna is quite insistent that the certainty, and thus the necessity, in question in a demonstration is not merely the certainty or necessity of the conclusion; for that the conclusion follows of necessity or certainly is true of every valid syllogism. For Avicenna, then, the relevant certainty or necessity concerns the premises, and the certainty or necessity of the conclusion is in turn derived from the premises' certainty or necessity."

II. AIM AND CLASSIFICATION OF SCIENCES

In a special treatise entitled *Risālah fī Aqsām al-ʿUlūm al-ʿAqliyyah* Ibn Sīnā gives an elaborate classification of the so-called intellectual or rational sciences,[28] which were often contrasted with the religious and traditional sciences (*ʿulūm sharʿiyyah naqliyyah*). Like al-Kindī before him, Ibn Sīnā takes science–in the broadest sense designating a systematic body of knowledge encompassing all disciplines (*ʿulūm*)–to be a synonym of wisdom and therefore uses the terms *falsafah* and *ḥikmah* interchangeably. He starts by giving a definition of 'science':[29]

> Science is the intellectual endeavor of human being to grasp the totality of existence and to learn whatever necessary for him to do in order to refine his soul and to acquire an accurate understanding of the world and to attain the ultimate happiness in the Afterlife, as far as his capacity allows. [30]

Three points are worth noting in this passage. First, science is, for Ibn Sīnā, an attempt to understand and explain reality in rational terms. Second, science is aimed at satisfying not merely the cognitive needs of human beings but also their spiritual needs. Finally, science is supposed to help scientists accomplish the higher, immaterial goal: happiness in this world and the next. Here we observe the difference between Ibn Sīnā's conception of science and our modern, secular view of science.

Science is broadly divided into theoretical (*naẓarī*) and practical (*ʿamalī*). The aim of theoretical science is to acquire truth and certainty (*ḥuṣūl al-iʿtiqād al-yaqīnī*) about things

28 Ibn Sīnā, "Risālah fī Aqsām al-ʿUlūm al-ʿAqliyyah," in *Tisʿ Rasāʾil fī al-Ḥikmah wa al-Ṭabīʿiyyāt* (Cairo: Maṭbaʿah Hindiyyah, 1326/1908), 104-13; translated into French by Georges C. Anawati, "Les divisions des sciences intellectuelles d'Avicenne," in *Mélanges de l'institute domincain d'études orientales MIDEO* 13 (1977), 323-35.

29 One must be careful here not to impose the modern reductionist conception of 'science' as something distinct from 'philosophy'. Indeed, until the 17th century 'philosophy' was practically indistinguishable from 'science', hence what we now call physics or natural sciences were labeled "natural philosophy" in Ibn Sīnā's day, a usage that continued for centuries to the time of Newton who gave his famous work the title: *Principia mathematica philosophiae naturalis*.

30 Ibn Sīnā, "Risālah fī Aqsām al-ʿUlūm al-ʿAqliyyah," 104-5: "*al-ḥikmah ṣināʿat naẓar yastafīd minhā al-insān taḥṣīla mā ʿalayhi al-wujūd kulluhu fī nafsihi wa mā ʿalayhi al-wājib mimmā yanbaghī an yaksibahu fīʿluhu li-tashrafa bi-dhālika nafsuhu wa tastakmiul wa taṣīru ʿāliman maʿqūlan muḍāhiyan li al-ʿālam al-mawjūd wa tastaʿiddu li al-saʿādah al-quṣwā bi al-ākhirah wa dhālika bi-ḥasab al-ṭāqat al-insāniyyah.*"

that exist objectively and independently of man and his acts. Theology and metaphysics belong to theoretical sciences. The practical sciences have a different goal; they are studied not for the sake of attaining truth or certainty about the world, but rather to obtain a correct view about things necessary for man in order to be good. In short, whereas the theoretical sciences are concerned with truth (*al-ḥaqq*), the practical sciences are means to find the good (*al-khayr*).[31]

The theoretical sciences have three classes: the natural sciences being in the lowest, the mathematical sciences in the middle, and metaphysics regarded supreme. Natural sciences lie in the lowest rank because they deal with objects that are logically and ontologically related to physical matter and change, such as [the science of] spherical bodies and the four elements as well as the various conditions like motion and rest, alteration and transformation, generation and corruption, and qualities from which those conditions sprung. Mathematical sciences are slightly different because they study abstract entities that are related to matter ontologically though not logically, such as numbers, shapes and figures. As for metaphysics, its objects are totally abstract, entities that are ontologically and logically independent of matter and change, such as essence and existence, unity and plurality, individuality and universality, causality, etc.

The practical sciences are of three kinds: one concerned with the well-being of man as individual, the other with the management of man as members of a household and, finally, as members or citizens of the state. The first of these is called ethics, the second economics, and the last one politics. Ibn Sīnā explicitly mentions Aristotle's *[Nicomachean] Ethics* and Plato's *Republic* as indispensable references on this.

The natural sciences are broken down into the 'principal' (*aṣlī*) and 'corollary' (*farʿī*). Eight sciences belong to the principal ones: (i) physics; (ii) on the heavens and the universe; (iii) on generation and corruption; (iv) meteorology; (v) on minerals; (vi) on plants; (vii) on animals; (viii) on the soul. The corollary natural sciences are seven: (i) medicine; (ii) astrology (*ʿilm aḥkām al-nujūm*); (iii) physiognomy (*ʿilm al-firāsah*); (iv) oniromancy (*ʿilm al-taʿbīr*); (v) the science of talismans (*ʿilm al-ṭalismān*), (vi) theurgy or magic (*ʿilm al-nīranjiyyāt*), and (vii) alchemy (*īlm al-kīmyā'*).

The mathematical sciences include four principal parts: (i) arithmetics (*ʿilm al-ʿadad*); (ii) geometry (*ʿilm al-handasah*); (iii) astronomy (*ʿilm al-hayʾah*); (iv) musics (*ʿilm al-mūsīqā*); each of these being further divided as follows: arithmetics into the Indian art of calculation and algebra; geometry into geodesy (*ʿilm al-masāḥah*), engineering (*ʿamal al-ḥiyal*), optics

31 Ibn Sīnā, *Risālah fī Aqsām* al-ʿUlūm al-ʿAqliyyah, 105.

(*ʿilm al-manāẓir wa al-marāyā*), the science of weights and balances (*ʿilm al-awzān wa al-mawāzīn*), of mechanics (*ʿamal jarr al-athqāl*) and hydraulics (*ʿilm naql al-miyāh*); astronomy into the art of making astronomical tables and calendars (*ʿilm al-zījāt wa al-taqāwīm*); musics into the art of handling various instruments.

Metaphysics is divided into five principal parts: (i) the study of general concepts (*al-maʿānī al-ʿāmmah*) [i.e. ontology]; (ii) of the principles and foundations (*al-uṣūl wa al-mabādiʾ*) of the sciences; (iii) of the First Truth (*al-Ḥaqq al-Awwal*); (iv) of the primary and secondary spiritual substances (*al-jawāhir al-rūḥāniyyah*); (v) of the relationship between the celestial and terrestrial substances. Three corollary parts include investigation into the nature and modality of Divine revelation (*al-wahy*) and inspiration (*al-ilhām*), the phenomena of miraculous events (*karāmāt wa muʿjizāt*), the nature of prophecy (*nubuwwāt*), angelology and eschatology (*ʿilm al-maʿād*).[32]

No doubt, Ibn Sīnā was not the first to classify sciences. Before him al-Kindī (d. *ca.* 236/850) and al-Fārābī (d. 339/950) had been concerned with classification of sciences and the consequent interrelation of all branches of knowledge.[33] Various reasons have been put forth to make sense of the classification of sciences by these philosophers. S.H. Nasr holds that it represents an effort to integrate the different sciences, both intellectual and religious, in line with the Islamic principle of *tawḥīd*.[34] He also believes that such classification of knowledge reflects the ontological reality; sciences are classified according to the diversity and structure of objects that make up the world. Both of these views are rejected by D. Gutas, who contends that the purpose of such classification was initially descriptive and pedagogical and only later did it acquire 'normative value'.[35] Here one needs only realize that classification such as made by Ibn Sīnā not only points to the fact that each discipline can be distinguished from others

32 Ibid, 105-15.

33 Al-Kindī wrote *Aqsām al-ʿUlūm*, while al-Fārābī wrote *Iḥṣāʾ al-ʿUlūm*. For further discussions, see: A. Cortabarria Beitia, "La classification des sciences chez al-Kindi," in *Mélanges de l'institute domincain d'études orientales (MIDEO)* 11 (1972), 49-76; and Muhsin Mahdi, "Science, Philosophy, and Religion in Alfarabi's Enumeration of the Sciences," in *The Cultural Context of Medieval Learning*, ed. J.E. Murdoch and E.D. Sylla (Dordrecht: Reidel, 1975), 113–147. Other relevant literature includes: Hans Daiber, "Qosta b. Luqa (9. Jh.) über die Einteilung der Wissenschaften," in *Zeitschrift fuer die Geschichte der Arabisch-Islamischen Wissenschaften,* 6 (1990), 93-129; Wolfhart Heinrichs, "The Classification of the Sciences and the Consolidation of Philology in Classical Islam," in *Centres of Learning: Learning and Location in Pre-Modern Europe and the Near East,* ed. Jan Willem Drijvers and Alasdair A. MacDonald, (Leiden: Brill, 1995), 119-39.

34 Seyyed Hossein Nasr, "The Achievements of Ibn Sīnā in the Field of Science and his Contributions to Its Philosophy", in *Islam & Science*, vol. 1 (2003).

35 Dimitri Gutas, "Medical Theory and Scientific Method in the Age of Avicenna" in *Before and After Avicenna,* ed. David C. Reisman and Ahmed H. al-Rahim (Leiden: Brill, 2003), 146.

whether with respect to the object under investigation or with respect to the mode or method of investigation. More importantly, it purports to show the hierarchical nature of the division between different disciplines, mirroring as it were the ontological hierarchy found in reality.

As Ibn Sīnā makes explicitly clear in the *Isagoge* of his kitāb *al-Shifāʾ*, one of the reasons why he like Aristotle classifies knowledge into theoretical and practical is that reality itself, which comprises all existent things (*al-ashyāʾ al-mawjūdah*), are also divided into two classes: (i) those which exist despite or beyond our will and act *(laysa wujūduhā bi-ikhtiyārinā wa fiʿlinā)* and (ii) those which exist because of our will and act (*ashyāʾ wujūduhā bi-ikhtiyārinā wa fiʿlinā).* While the former is dealt with in the theoretical sciences, the latter becomes the subject-matter of the practical sciences.[36] Still one may add that such classification as done by Ibn Sīnā, derived as it is from the Greek sources, nonetheless has something of the nature of the religious concepts which he no doubt subscribes to and therefore may be regarded as part of the 'naturalization' (or –as some would rather say– 'islamization') process.

III. INDUCTIVE AND EXPERIMENTAL METHOD

The next issue tackled by Ibn Sīnā is whether scientists should use and may rely on induction and experiment in their research or not. Induction (*istiqrāʾ*) is an argument or reasoning from particulars to universal, that is, to infer a general claim (such as theory or law) from a number of its particular instances. In modern times, the so-called problem of induction has troubled many philosophers of science from Maxwell to Popper: how are we to explain the reliability of arguments of the type "Every *x* observed so far is *y*; therefore, every *x* without qualification is *y*" or "Every *x* is generally *y* because every *x* observed so far is *y*." They want to ascertain the legitimacy of drawing conclusions about what we have not encountered from generalizations about what we have.

Having defined induction as a judgement applied to the whole class, set or group on the basis of its applicability to some of the individual parts or members (*ḥukm ʿalā kullī li-wujūd dhālik al-ḥukm fī juzʾiyyāt dhālika al-kullī*),[37] Ibn Sīnā gives the following example: since one has observed that a product is made by a producer, one therefore infers that everything, say,

36 Ibn Sīnā, *al-Shifāʾ: al-Manṭiq: al-Madkhal*, 12.

37 Ibn Sīnā, *al-Najāt*, ed. Mājid Fakhrī (Beirut: Dār al-Āfāq al-Jadīdah, 1405/1985) 93.

a house, must also have a producer. This is an argument from effect to cause (*istidlāl bi al-maʿlūl ʿalā al-ʿillah*) widely used by theologians: the world must be created by a Creator (God) because, like everything else we observe, it is composed of parts and has a beginning in time. According to Ibn Sīnā, however, this kind of reasoning cannot lead us to permanent certainty (*laysa mimmā yaqaʿ bihi al-yaqīn al-dāʾim*), because what is true of the part may not be true of the whole (*iʿtibār al-juzʾ ghayr iʿtibār al-kull*).[38] The observed fact that many things around us are made or produced by some maker or producer does not necessarily allow us to infer that everything that exists must be created by a creator. Indeed, on closer analysis, induction turns out to be nothing more than analogy (*tamthīl*), which is considered the weakest of arguments. Inductive inferences have one common flaw that sharply distinguishes them from deductive or syllogistic reasoning: they can be easily rendered invalid and refuted by a single counter-example that would be sufficient to block the logical move from any number of cases (some *x* are *y*) to the generalization that all *x* are *y* or every *x* is *y*. So Ibn Sīnā remarks, unless they take all particular cases and instances into account (*mustawfiyan li al-aqsām*), inductive inferences can only yield conjectural results (*al-ẓann al-aghlab*).[39]

Interestingly, however, Ibn Sīnā stresses the importance of empirical testing (*tajribah*) or experimentation, even though it resembles induction in procedure. According to him, if experimentation leads to certain knowledge it is not owing to repeated observation alone, but rather due to the syllogism accompanying it. Further, the kind of knowledge experimentation affords us is not universally and absolutely true; it is only conditionally true. That is to say, it is true only insofar as repeated experience tells us and insofar as there is no impediment (*illā an yakūn māniʿ*) preventing or obstructing the relation of cause to its effect. This is why experimentation often leads to errors, particularly if what is accidental is mistaken for what is essential.[40] Experimental method can yield certainty only when it is done properly, in accordance with the rules such as he outlines in *al-Qānūn fī al-Ṭibb*[41] in the beginning of the section on drugs.

Some of the conditions set by Ibn Sīnā to ensure a reliable experimental investigation of the effects of drugs used to cure human diseases are as follows: (i) the experiment should be done with a simple and not a complex disease, for in the second case it would be impossible

38 Ibn Sīnā, al-Shifāʾ: *al-Manṭiq: al-Burhān*, 87-89.
39 Ibid, 95.
40 Ibid, 96.
41 Details on the text and its reception in Medieval Europe, see Marie-Thérèse d'Alverny, *Avicenne en Occident* (Paris : J. Vrin, 1993), sect. XV.

to infer from the cure what was the curing cause in the drug; (ii) the drug must be tested with two contrary types of disease, because sometimes a drug cures one disease by its essential qualities and another by its accidental ones; (iii) the time factor should be taken into account and constant observation must be performed; (iv) finally, the experiment must be done with the human body, for testing a drug on a lion or a horse might not prove anything about its effect on humans.[42]

Concluding Remarks

In light of the foregoing discussion we may be justified to claim that Ibn Sīnā was indeed a philosopher of science as much as Aristotle was. One need only recall the fact that his interest and works cover various fields of science from physics to medicine, psychology, and music, many of which (e.g., kitāb *Shifāʾ*) were prompted by a perceived need to provide science with a rational foundation that would be acceptable universally, and to integrate the various sciences known up until his time. Ibn Sīnā's philosophy of science is a synthesis drawing upon many sources, mainly Aristotelianism and Neoplatonism but also–I should like to add– the Islamic tradition, which is also true of other thinkers before and after him, since no man is an island. Yet Ibn Sīnā put the pieces together in a manner quite different from his predecessors, and he often offered new arguments to clarify and justify his positions. Understanding how Ibn Sīnā put all those pieces together would therefore shed light not only on the important aspects of his thought on science but also upon the larger history of the development of the philosophy of science in the medieval times.

42 Ibn Sīnā, *al-Qánūn fī al-Ṭibb* (Cairo: al-Maṭbaʿah al-Amīriyyah, 1877), 1: 224-5 = (New Delhi: Maʿhad Tārīkh al-Ṭibb wa al-Abḥāth al-Ṭibbiyyah, 1408/1988), 2: 5-6 = Avicenne, *Liber Canonis Medicine cum castigationibus Andreei Bellunesis* (Venice?, MDXXIII), 69v-70r.

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