Avicenna's Naturalized Epistemology and Scientific Method*

Jon McGinnis

Abstract This study provides a survey of Avicenna's theoretical or abstract discussions of the methods of science and the psychological processes laying behind them as they appear in his *Kitāb al-Burhān*. Since that text has not been studied in-depth, the chapter is primarily exegetical, focusing what might be termed Avicenna's 'naturalized epistemology'. The study is divided into two sections. The first treats Avicenna's theory of demonstrative knowledge, and how Avicenna envisions the relation between logic and science, where it is argued that one of the primary functions of *Kitāb al-Burhān* is to provide heuristic aids to the scientist in his investigation of the world. The second half concerns Avicenna's empirical attitude in *Kitāb al-Burhān* towards acquiring the first principles of a science, where such cognitive processes as abstraction, induction and methodic experience are considered.

No treatise by Avicenna, at least not among his major philosophical encyclopedias, is exclusively dedicated to what might be called 'traditional epistemology'; rather, Avicenna's theory of knowledge is found in his psychological works and his work on scientific method, namely, *Kitāb al-Burhān*. By 'traditional epistemology' I mean the investigation into how knowledge or science is possible in the light of skeptical challenges. The traditional epistemological answer involves identifying a set of foundational criteria—whether *a priori* truths, sense data or a combination of both—by which one can justify or verify certain beliefs, and so can be said to have justified, true beliefs, that is, knowledge or science. In contrast with traditional epistemological approaches a naturalist approach to epistemology has re-emerged among contemporary philosophers. Paul Roth describes this naturalized epistemology thus:

> Naturalism in epistemology can be characterized negatively by its eschewal of any notions of analytic or *a priori* truths. Positively, naturalism asserts a normative and methodological continuity between epistemological and scientific inquiry. The techniques endemic to the former are only a subset of the historically received and contingently held norms and methods of the latter (Roth (1999, 88)).

J. McGinnis
University of Missouri, St. Louis Department of Philosophy, 599 Lucas Hall (MC 73) One University Blvd. St. Louis, MO 63121-4499 USA
e-mail: mcginnis@umsl.edu

S. Rahman et al. (eds.), *The Unity of Science in the Arabic Tradition*,

Bearing in mind these two opposing approaches to the theory of knowledge, it is worth noting that in Avicenna's works on psychology and scientific method he does not obsess over how to respond to the skeptic, or how to provide an *a priori* foundation for knowledge or even how to justify the knowledge one claims to have.[1] His concern is with describing the psychological processes involved in knowledge acquisition as well as the proper methods employed by successful scientists within the various sciences. In short, for Avicenna the traditional epistemological question, "How *ought* we acquire our beliefs?" is replaced, or at the very least is answered in part by, the question "How *do* we acquire our beliefs?", where the normativity of reason is in fact grounded in the practices of good science.

It is Avicenna's emphasis on this latter descriptive question as opposed to the former normative question, as well as his appeal to the *a posterior* as opposed to the *a priori* that I am calling 'Avicenna's naturalized epistemology'.[2] In this respect the type of foundationalism I am denying of Avicenna is a rather strong one, namely, an epistemological theory that asserts that the justification or verification of a body of beliefs must ultimately be based on what contemporary philosophers have variously termed '*a prior* truths', 'self-evident truths', 'self-presenting truths', and 'the given'. Foundationalism in this sense should not be confused with the thesis that certain sciences may be subordinate to other sciences, as for example physics might be thought to be more basic than chemistry. In the case of subordinate sciences the higher science frequently provides the explanations of various principles simply assumed in the lower science. This latter position more properly belongs to projects of unifying the sciences rather than epistemic foundationalism, and one can happily endorse one, while not endorsing the other, as in fact Quine did.

As already noted those interested in Avicenna's theory of knowledge must look predominately to either his psychological works or his work on demonstration. Since most current research has focused on Avicenna's psychological treatises, I want to augment our understanding of Avicenna's theory of knowledge by considering his far less studied *Kitāb al-Burhān* of the *Shifā'*. Since this work has not been studied in-depth, my intent in this chapter is primarily exegetical, namely, to present a number of the more salient features of *Kitāb al-Burhān*.[3] In addition, however, I shall argue for what I have called Avicenna's 'naturalized epistemology'. This involves two stages. First, I treat Avicenna's theory of demonstrative knowledge, and how Avicenna envisions the relation between logic and science, where I contend that *Kitāb al-Burhān*, far from endorsing any foundational project in epistemology, is primarily concerned with providing heuristic aids to the scientist in his investigation of the world. The second stage concerns Avicenna's empirical attitude in *Kitāb al-Burhān* towards acquiring the first principles of a science, where I consider the cognitive processes of abstraction and to a lesser extent induction and methodic experience.[4]

1 Demonstrative Knowledge

Avicenna's *Kitāb al-Burhān* roughly follows Aristotle's *Posterior Analytics*, although Avicenna's organization and development of Aristotelian themes are often uniquely his own. It is worth noting that among contemporary Aristotelian scholars it is an open question whether Aristotle intended the *Posterior Analytics* to be a discussion of science in general, or of some specific sciences and not others, or indeed whether it merely presents an account of how to formalize for pedagogical reasons a science already obtained.[5] The situation is not the same for Avicenna's *Kitāb al-Burhān*. Avicenna clearly saw this work as providing a completely general philosophy of science applicable to all sciences. "The goal of this book is to provide a means for acquiring the assent that is certain and the true and real concepts, and so the benefit of the book is obvious, namely, to arrive at the sciences occasioning certainty and the true and real concepts beneficial to us" (I.1, 7.12–14; 53.15–14). Moreover, this conception of the goal of *Kitāb al-Burhān* is witnessed by Avicenna's regular use of examples drawn from all the sciences, such as medicine, physics, mathematics and metaphysics.

For Avicenna knowledge or scientific understanding (Arabic علم; Greek ἐπιστήμη) is roughly divided into two kinds: knowledge of the first principles of a given science and knowledge acquired through demonstration. Avicenna notes that both an account and description of how one acquires the first principles of a science properly fall under the purview of psychology (III.5, 160.17–18; 222.12–13), whereas a discussion of the methods and tools used by the scientist in acquiring demonstrative knowledge belongs to the subject of *Kitāb al-Burhān*; nevertheless, Avicenna does make comments in *Kitāb al-Burhān* relevant to how the scientist acquires the first principles of a science, which I shall turn to in the second half of this chapter. For now, however, I begin with his discussion of demonstrative knowledge and the demonstrations leading to it.

Unlike Aristotle, who at *Posterior Analytics* I 2 offered a list of the conditions that the premises in a demonstration must meet—namely that they are true (ἀληθές), primitive (πρῶτον), immediate (ἀμέσον) (that is, not themselves derived demonstratively), better known than (γνωριμώτερον), prior to (πρότερον) and explanatory of (αἴτιον) the conclusion—Avicenna offers no such succinct list. Instead Avicenna's discussions of the conditions required of scientific first principles are interspersed throughout book I of *Kitāb al-Burhān*, sometimes treated explicitly, but more frequently implicitly. Thus Aristotle's 'truth condition' appears to be subsumed under Avicenna's 'certainty condition' (يقين), which includes both being true or real (الحقّ) and necessary (الضروري) (I.7 30.17–31.10; 76.4–14). Avicenna's use of 'certainty', a condition conspicuously absent from Aristotle's list, is significant. Throughout *Kitāb al-Burhān* Avicenna uses 'certainty' in two conceptually distinct ways.[6] 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. For Avicenna, as we shall see, one has the former type of certainty, that is, psychological assurance, only when one is aware of the latter type of certainty, that is, one recognizes that a necessary or inevitable causal relation obtains between two things. Here we should also note that though Aristotle himself does not include necessity in his initial list of conditions for the premises of a demonstration, based upon what he does say at *Posterior Analytics* I 4 and 6, it is natural enough to think that he thought necessity was a hallmark of such principles. Avicenna just makes this condition explicit in his notion of certainty.

Concerning the remainder of Aristotle's conditions, Avicenna, as far as I can see, never explicitly discusses the 'primitiveness' of principles, but this may be because أوّل ('primitive') is often taken as a synonym for 'principle', and so it might have been thought that this condition must obviously hold of a principle. As for being 'immediate', Avicenna mentions in passing at I.6 (30.10–12; 77.3–5) that some knowledge is بلا واسطة ('without middle'), but he probably does not intend this condition to be an absolute requirement of a scientific principle, but only relative to a given science; for he clearly believes that some of the principles in a subaltern science might be demonstrated in a higher science (I.12, 58.14–17; 110.13–15). At *Kitāb al-Burhān* I.11 Avicenna has a detailed discussion of the conditions 'prior to' (أقدم) and 'better known' (أعرف) than the conclusion, in which, like Aristotle, he distinguishes between 'prior and better known to us' and 'prior and better known by nature'. Unfortunately, his extremely rich and nuanced discussion is worthy of a study in its own right and would take us well beyond the scope of this chapter. Concerning Aristotle's final condition, 'causally explanatory of the conclusion', this condition too seems to be subsumed under Avicenna's certainty condition and will be discussed more thoroughly below.

A demonstration according to Avicenna is "a syllogism constituting certainty," (I.7, 31.11; 78.15). In other words, it is a deduction beginning with premises that are certain or necessary that concludes that not only such and such is the case, but that such and such cannot not be the case (I.7, 31.7–8; 78.11–12).[7] Thus, demonstrative knowledge involves possessing a syllogism that makes clear the necessity or inevitableness obtaining between the subject and predicate terms of its conclusion. In addition, Avicenna divides demonstrative knowledge itself into two categories depending upon the type of demonstration employed. Thus there is the demonstration *propter quid*, or demonstration giving 'the reason why' (برهان لِمَ) and the demonstration *quia*, or demonstration giving 'the fact that' (برهان لأن).[8] Avicenna further divides the demonstration *quia* into two sub-species: a demonstration that leads from one correlative effect to another correlative effect, called an "absolute demonstration *quia*" (برهان لأن على الإطلاق), and a demonstration that leads from an effect to the cause, called an 'indication' (دليل).

Concerning the two types of demonstration *quia*, Avicenna suffices himself with providing definitions and examples of both kinds. Thus the absolute demonstration *quia* "accords with the existing middle term's neither being a cause nor an effect of the major's existing in the minor; rather, [the middle term] is something related to or coextensive with [the major term] in relation to its cause, where [the

middle term] accidentally accompanies it or something else simultaneous with it in the nature" (I.7, 32.7–10; 79.17–19). He gives the following syllogism as an example: whoever exhibits a cloudy viscous urine is feared to have encephalitis; this individual (who is suffering from a fever) has exhibited such symptoms; thus this individual is feared to have encephalitis. In this case, notes Avicenna, neither the symptoms nor having encephalitis is the cause or effect of the other; rather, they are both effects of some unstated cause, which Avicenna identifies with the heated humors' motion towards the head and their evacuation from it. What is important to note about the absolute demonstration *quia* is that even though the syllogism neither proceeds from nor leads to a cause, there nonetheless is a necessary, natural causal relation between the two terms, namely, they both are effects of some common cause, even if that cause is not made explicitly clear in the syllogism. Had there been no such causal relation, and the two terms had been merely coincidental accidents, then there would have been no demonstration. We shall return to this point shortly.

The second of the two demonstrations *quia*, namely, an indication, "accords with [the middle term's] existing as the effect of the major's existing in the minor" (I.7, 32.10; 79.19–20), and here Avicenna provides several examples. For instance, every recurring tertian fever is a result of the putrefaction of bile; the individual (who is suffering from a fever) has a recurring tertian fever; therefore, his fever is a result of the putrefaction of bile. Similar examples are given concerning the Moon's relative position in relation to the Sun and the Moon's various phases; the Moon's being eclipsed when it passes between the Earth and the Sun; and a piece of wood's burning when put into contact with fire. What is common in these examples is that one starts from some effect and concludes to the effect's cause.

Demonstration in the most proper sense is the demonstration *propter quid*. The demonstration *propter quid* is a syllogism "that gives the cause with respect to both issues [namely, *that* such and such is the case as well as *why* such and such is the case], such that [the syllogism's] middle term is like the cause for granting assent to the major's existence belonging to the minor (or its denial), and so it is a cause of the major's existence belonging to the minor (or its denial)" (I.7, 32.5–7; 7913–16). In his examples of the demonstration *propter quid*, Avicenna returns to the examples used in clarifying an indication, but now he converts the examples such that the middle term is the cause of the effect. Thus, he again gives the example of tertian fever: whoever suffers from a putrefaction of bile owing to the bile's congestion and the pores being obstructed is suffering from a recurring tertian fever; this individual is suffering from these symptoms; therefore, this individual is suffering from a recurring tertian fever. In short, the demonstration *propter quid*, like the demonstrations *quia*, inherently involves necessary, natural, causal relations. Unlike the demonstrations *quia*, however, the demonstration *propter quid* makes clear exactly what that causal relation is.

As Avicenna's examples suggest, he believes that there is an inherent relation between demonstrations and causes. At *Kitāb al-Burhān* I.8 he develops this line of thought and argues in two steps that there is demonstrative knowledge if and only if one has necessary, perpetual certainty concerning the relation between two terms, where this certainty only occurs when one recognizes that a causal relation

holds between the two terms. Avicenna's first step is to indicate that knowledge of causal relations provides this necessary, perpetual certainty. His second step is to show that other kinds of relations that purport to provide this type of certainty in fact do not do so.

In *Kitāb al-Burhān* Avicenna's first stage—namely, indicating that the knowledge of causes ensures necessary, perpetual certainty—is example driven and he defers a full account of the underlying metaphysics of causality to first philosophy.[9] For our purposes it would be beneficial to consider one of Avicenna's metaphysical arguments for this thesis. The argument that I shall consider, though by no means Avicenna's most well known or even preferred argument for causal necessity, does have the advantages of being concise as well as highlighting a point that will be of interest later, namely, how one comes to know that something has a causal power.[10]

In the *Najāt* (XI.2.i, 546.3–547.5), Avicenna begins with the claim that any proposition is necessary whose opposite entails an absurdity (محال) or a contradiction in the sense defined in Aristotle's *Metaphysics*, namely that something cannot both be and not be at the same time and in the same respect (Γ 4, 1005b19–20). Now grant, for example, that fire, which has the actual active power to burn, is put into contact with cotton, which has the actual passive power to be burned. Next assume that the expected effect, namely, the burning of the cotton, does not occur. Under these conditions one of two things would explain the cotton's not burning. Either the fire, which was assumed to have the actual active power to burn, does not in fact have the active power to burn, and thus there is a contradiction; or the cotton, which was assumed to have the actual passive power to be burned, does not in fact have the passive power to be burned, which again is a contradiction. In either case, then, the assumption that the expected effect does not occur, given the actual presence of its causes, entails an absurdity or contradiction. Thus, the opposite of the assumption must be necessary, namely, the expected effect necessarily occurs given the actual presence of its causes.

The previous argument might appear to be a piece of *a priori* reasoning, opposed to the sort of naturalism that I want to ascribe to Avicenna. On closer examination, however, one sees that the content of the argument requires that one already knows that things such as fire and cotton have their respective active and passive causal powers. This knowledge, as we shall see in the second half of this chapter, is not known *a priori*, but is acquired either through a process of abstraction (التجريد) or methodic experience (التجربة), both of which, as I shall argue, involve a strong empirical element. In this respect, then, Avicenna's argument is clearly not intended to show *that* there are causal relations by some piece of *a priori* reasoning. In a very real sense Avicenna just takes the reality of causal relations for granted as part of his naturalism; for to deny causal relations would make the events in the world matters of mere happenstance and so would leave unexplained the manifest regular and orderly occurrence of events. In effect, to deny causal relations would undermine the very possibility of science understood as an investigation and explanation of the world's order, a position that Avicenna simply will not countenance. Instead, Avicenna's argument shows that

to deny that causal relation are necessary is in effect to deny causal relations outright and so give up on the project of science.

Avicenna's second stage in arguing that demonstrative knowledge is only acquired through knowing causes is to show that other kinds of relations that purport to provide necessary certainty in fact do not do so, or in the very least do not provide scientifically informative knowledge. Avicenna does not provide a global argument for this thesis, but proceeds on a case by case basis, where the two most prominent cases are the so called 'relative syllogism'[11] and cases of repetition or exclusion (الإستثناء).

Concerning the relative syllogism, one might argue as follows: Zayd is a sibling; all siblings have a sibling; therefore Zayd has a sibling. In this case one has argued from the relation of being a sibling to the existence of Zayd's sibling, where being a sibling is not the cause of the existence of the other individual, and yet one knows with certainty that the other individual exists given that Zayd is a sibling. Although Avicenna undertakes "a close examination and analysis" of the logic underlying this case, his concluding remarks suffice for our purposes.

> Know that the intermediacy of the relative is something of little profit with respect to the sciences. That is because your knowledge that Zayd is a brother is your very knowledge that he has a brother or it is something included in your knowledge of that. Thus the conclusion is no better known than the minor premise. If that is not the case, and instead one is ignorant of [the conclusion] until it is proven that [Zayd] had a brother, then the individual simply does not understand (تصوّرت) "Zayd is a brother." Cases such as these should not be called syllogisms let alone demonstrations (I.8, 41.18–42.1; 90.3–7).

Inasmuch as science and demonstrative knowledge are intended to provide one with a deeper understanding of the workings of the world, relative syllogisms simply fail; for, as Avicenna observes in his detailed analysis of the relative syllogism, to recognize a relation is simply for "the two relata to be simultaneously present in the mind" (I.8, 41.10–11; 89.15–16). In other words, it is not the relation that makes clear the existence of the two relata, but the existence of the two relata that makes clear the existence of the relation.[12]

Avicenna next considers the case of الإستثناء, which we shall leave un-translated for the moment. He gives the following example where one seems able to draw a conclusion with necessary certainty and yet the conclusion is not causally related to the premises.

> When we know that this number is not one of two, we know with absolute unchanging certainty through the intermediary of ['its not being one of two'] that [this number] is singular. Now that does not result from a cause; for it is not the case that its not being one of two is a cause of its being singular; rather, it is more appropriate that its being singular is something that in itself is a cause of its not being one of two and is something external to the essence of [not being one of two], since it is through a consideration of something else [41.1–4; 89.6–10].

The purported counterexample involves a hypothetical syllogism of the form 'if not *p*, then *q*; not *p*; therefore *q*'. Here one infers the necessary and certain existence of *q* from the non-existence of *p*, but the non-existence of something can hardly be called a 'cause', at least not in any rich sense of cause as some real ontological feature of the world, which of course is what Avicenna intends.

Although Avicenna's resolution of this objection is relatively clear, the target or scope of his solution is not as clear. As for his solution (I.8, 42.1–7; 90.8–14), he argues that the middle term is either (1) some characteristic or sign (علامة) that does not essentially require that the number not be one of two or (2) one knows that the number is not one of two owing to some cause. In the first case, where there is nothing belonging to the essence of the number that requires that the number not be one of two, one does not know the premise with necessary, unchanging certainty. If the initial premise is not known with certainty, however, then neither can the conclusion be known with certainty; and so one cannot be said to have scientific understanding of the conclusion. In the second case, where there is something belonging to the essence of the number that explains its not being one of two, the cause would be that the number is singular and so by knowing that it is singular, one knows that it is not one of two. In that case, however, one already knows the conclusion before one knows the premise, and as such the conclusion of the purported example is uninformative and so not scientifically interesting.

The difficulty is determining the scope of Avicenna's conclusion, that is to say, what does Avicenna precisely mean by الإستثناء. He clearly does not mean الإستثنائي القياس, or the 'repetitive syllogism' understood as an entire class, since at the end of his discussion he contrasts the counterexample with the informative repetitive syllogism, which conclude to some new knowledge acquired only after the 'repetition' (الإستثناء).[13] In this case, Avicenna may be critiquing any syllogism that uses a conditional premise, where the antecedent and consequent of the conditional are not causally linked. Alternatively, Avicenna may be using الإستثناء in a non-technical sense, and so may mean simply 'exemption' or 'exclusion'. Thus, Avicenna may be concerned with proofs that purport to provide necessary certainty about some class of things on the basis that a given class of things is exempt or excluded from some other class of things. In this case the exemption or exclusion may be treated as a type of negation, where a negation is hardly a cause in the sense of some real ontological feature of the world.

Perhaps we do not need to choose between these two alternatives; for it would seem that Avicenna has the philosophical wherewithal to exclude from the purview of scientific knowledge both types of proofs, again, namely, those involving no causal link between the elements of a conditional proposition and those involving negations. In the first case, it must be shown that Avicenna's original argument can be generalized to exclude from scientific discourse all hypothetical syllogisms in which there is absolutely no link between the antecedent and consequent of the conditional premise or premises. Clearly the first horn of the argument can be generalized, since if one of the premises is not known with certainty, then the conclusion cannot be known with certainty either. The difficulty is with the second horn, since perhaps there is some third thing that essentially explains the correlation, and yet the conclusion is not explanatory of the premise, as appears in Avicenna's own version of the argument. To give a hackneyed example: if something does not have a heart, it does not have a kidney; *x* does not have a heart; therefore, *x* does not have a kidney. Structurally, this example is identical with Avicenna's own; however, not having a kidney certainly is not the cause of not having a heart, or vice versa, but it was precisely that the

conclusion was causally explanatory of one of the premises that Avicenna found objectionable in his initial argument. Still, if one knows with necessary, unchanging certainty that there is a necessary correlation between the two, even though not necessarily a direct cause-effect relation between them, that knowledge will presumably be on the basis of possessing an absolute demonstration *quia*, but in that case knowing that *x* does not have a heart is to know that *x* does not have a kidney. Thus one would have concluded to something already known, and so the syllogism is uninformative and not suitable for providing scientific knowledge. In short, the argument of Avicenna's second horn might be generalized thus: if two things are not merely related by happenstance, then to know that they are essentially related requires possessing an absolute demonstration *quia*; however, if one already possesses an absolute demonstration *quia* that two effects are essentially dependent upon a single cause, then given the existence of one effect one already knows that the other effect must exist. Simply put, such cases of الإستثناء will be scientifically uninformative.

Alternatively, if Avicenna intended الإستثناء to indicate a type of negation rather than a sub-class of repetitive syllogisms, he could draw on earlier arguments he presented in the *Introduction* (المدخل) of the *Shifā'*. There he argued that though negations have a place in logic, they should be avoided in scientific discourse precisely because a negation inasmuch as it is a negation does not refer to any positive feature in the world, and yet science is concerned about finding out the way the world *is*. For Avicenna, negations are rather "entailments that belong to things relative to a consideration of certain (positive) accounts (معان) that do not belong to [the things]" (Avicenna (1952, I.13, 79.3–4)). In other words, when a proposition involves a negation, such as *x* is *not* one of two, the negation is relative to or follows upon certain positive accounts or factors that do belong to the thing, such as being singular, where the negative attribute is interpreted in terms of its failing to be among the positive accounts that do belong to the thing. As such negations are parasitic on what is. Thus insofar as الإستثناء might be understood as a type of negation, it provides one with information about the thing only to the extent that one already knows the causes or positive factors that constitute the thing, and so again negations are scientifically uninformative.

The relational syllogism and الإستثناء (however it might be understood) were the two main contenders for purported modes of necessary and certain reasoning that do not involve causal relations.[14] Both either failed to provide the requisite knowledge or were scientifically uninformative. Thus, demonstrative knowledge must concern causal relations; for only causal relations provide the necessary certainty that Avicenna takes to be the hallmark of good science.

To this point I have primarily focused on presenting and explaining the content of Avicenna's theory of demonstrative knowledge found in *Kitāb al-Burhān*. What should be clear from these comments is that for Avicenna there is an intimate link between logic and the scientific enterprise. I now would like to speculate about how I believe Avicenna envisions this relation. In the demonstration *propter quid*, as well as to a lesser extent the demonstrations *quia*, knowledge or scientific understanding is not for Avicenna about justifying one's beliefs or verifying science. Instead it is about laying bare the underlying causal structure of the world,

which is done primarily through a logical analysis of empirical data, where this analysis involves identifying the middle term ultimately required for rational thought. Here we are led to a fundamental epistemological insight—first articulated by Aristotle and then wholeheartedly embraced and developed by Avicenna—namely that the causal explanations sought in the various sciences are the middle terms used in logic.[15]

Whereas Aristotle appears simply to assert this identification in his *Posterior Analytics*, Avicenna, in other works, suggests what the underlying metaphysics might be that explains this relationship between the objects of science and the objects of logic. Thus in Avicenna's *Introduction* to the *Shifā'* and the *Metaphysics* of the *Najāt* he claims that there is something common to both the intelligibles, which are the objects of rational thought, and their concrete instances and the causal interactions among them, which are the objects of scientific inquiry. Thus, Avicenna writes in his introduction:

> The essences of things may be either in concrete particulars or in the conceptualization [of those things] (التصوّر), and so [essences] are considered from three [different] aspects. [One] aspect of essence indicates what it is to be that essence, not relative to one of the two existences [that is, concrete particulars or their conceptualization], and what follows upon them, [but only] insofar as it is thus, [that is to say an essence considered in itself]. [A second] aspect belongs to [essence] insofar as it is in concrete particulars, so that at that time accidents, which individualize its existing as that, follow upon it. [A third] aspect belongs to [essence] insofar as it is conceptualized, so that at that time accidents, which individualize its existing as that, follow upon it (Avicenna (1952, I.2, 15)).

Avicenna identifies the essence considered in itself—that is the common link between the particulars, or the objects of science, and the forms existing in the intellect, or the objects of logic and rational thought—with a certain 'thingness' (الشيئية).[16] Thus in the *Najāt*, he writes: "There is a difference between the thingness and the existence in concrete particulars; for the intrinsic essential account [of what something is] (المعنى) has an existence in concrete particulars and in the soul and is something common [to both]. That common thing, then, is the thingness" (XI.1.xii, 519.17–520.2).

For Avicenna, then, there is an inherent link between the objects of science and rational thought *via* the concept of thingness or the essence considered in itself. Although the two share a common link, they are, however, not absolutely identical for Avicenna; rather, as Avicenna will strenuously argue throughout the entirety of *Kitāb al-Burhān* I.10, the objects of science are in one sense prior to the objects of logic. Consequently, scientific analysis and examination are likewise in a sense prior to logical formulation, and as such logical notions are dependent upon and indeed mirror what is discovered as a result of good scientific methods. Hence, if an Aristotelian or Avicennan syllogistic provides humans with a universal logic, that is, a logic that sets the norms for rational thought (and there are good reasons for thinking that the *falāsifa*, including Avicenna, held this) and yet logical notions are dependent upon and reflect what is discovered through good scientific practices, then the way good science *in fact* proceeds is precisely the way one *ought* to acquire knowledge. In short, for Avicenna, epistemological questions concerning

the normativity of reason should be replaced, or at least informed by, descriptions of what science does.

The relationship between logic and science is central to Avicenna's naturalized epistemology, and thus we should be careful to state both what he intends and does not intend by this relation. Avicenna does not mean that by using logic one can rationally reconstruct the external world from sense data (or perhaps sense data and purportedly *a priori* truths) in the way Russell attempted in his *Our Knowledge of the External World*, and perhaps Carnap as well under one natural interpretation of his *Der logische Aufbau der Welt*.[17] For Avicenna such a foundationalist project would add nothing to one's understanding of how the world works, and thus in very real sense such a project would be vacuous for Avicenna. Moreover, such a project runs the risk of imposing some logical structure or constraints upon the world, which may not in fact be in the world, whereas for Avicenna the relation is just the reverse. Logic maps onto the way the world is, not because one has imposed some logical reconstruction on the world, but because the world structures and constrains the way one reasons about it.

For similar reasons Avicenna does not envision the relation between logic and science as how we might today see mathematics' standing to science, namely, as an idealization of the way the world would behave if it were composed of perfectly elastic bodies, lacking friction and the like.[18] Human cognitive faculties, for Avicenna, are such as to discover the causal structure inherent in the world itself, and even if humans can invent logically and mathematically idealized models of the world, this is at best derivative of first understanding the causal structures in the world.

For Avicenna, I contend, the significance of the relation between middle terms and causes is that it allows all the advancements made in logic (or at least Aristotelian and Avicennan logic) to be used to further one's scientific investigations and inquiries concerning the nature of the world. Here let me use an overly simplistic instance to make the point. For Avicenna one can express all inferences using a finite set of paradigm syllogisms. Moreover, the syllogism allows one to infer a relationship between two terms by means of a middle term; for example this individual's suffering from tertian fever follows from his suffering from a putrefaction of bile. Consequently, when the scientist seeks the causal explanation of some phenomenon (that is to say, he asks why a given relationship holds between two terms), he is assured that when there is a causal explanation that links the two terms, that relationship can be expressed as a syllogism. Furthermore, the causal explanation of this relationship serves as the syllogism's middle term. Thus, since all scientific demonstrations or discoveries are expressible syllogistically, and since the syllogism has a specific structure, the scientist can use his knowledge of the syllogism to guide his initial inquiries; for only premises of a certain form and arranged in a certain way constitute a valid syllogism. In short, since there is an inherent relation between causes, that is, the objects of scientific inquiry, and the middle term, that is, the fundamental notion of Aristotelian and Avicennan logic, the scientist can be assured that the logical features that belong to the syllogism likewise hold of scientific explanations. In short, the scientist can use his knowledge of logic to facilitate scientific investigation.

A concrete, even if overly simplistic, example may help clarify.[19] Imagine that a scientist wants to discover the cause of or reason why all dogs have incisors. For the Avicennan scientist, his knowledge of the syllogism immediately begins directing his search. The causal explanation must be of a form such that the conclusion "all dogs have incisors" follows logically. The only syllogism that renders such a conclusion is Barbara, namely, one that is in the first figure and has all universal affirmative premises. Hence the scientist knows before he begins his investigation that the answer (at least in its simplest form) has the following logical structure:

1. all *x* have incisors;
2. all dogs are *x*;
3. therefore, all dogs have incisors.

The scientist's inquiry, then, is for *x*, that is, the middle term that causally links dog and having incisors. Granted the syllogism has not provided the scientist with an answer to the inquiry, and thus the scientist must still undertake an empirical investigation. Still that one should investigate the world fits well with Avicenna's empiricist leanings, which I shall discuss more fully below. Furthermore, the scientist is steered clear of certain false avenues of pursuit. For instance, he can neglect any observations that hold only of some dogs or some of the things that have incisors.[20] Similarly, he can set aside those observations that hold of no dogs or no things that have incisors.[21] The reason he need not consider such premises is that one can never validly infer a positive, universal conclusion from them. Thus here is one way that logic's relation to science can facilitate scientific discovery, namely that a knowledge of the syllogism both allows the scientist to break down complex scientific questions into more manageable ones and also saves him from false steps in his investigation.

To summarize this section, demonstrative knowledge must concern causal relations; for only causal relations guarantee the necessary certainty that Avicenna takes to be the hallmark of science and knowledge. Moreover by linking the causal relations sought by scientists with the notion of the middle term, Avicenna could avail himself of the machinery presented in his logical works for the purpose of scientific investigations. Although there is much more to say about Avicenna's views of knowledge acquired through demonstration, the above at least gives one a sense of Avicenna's theory of demonstration and its relation to epistemology. In the last half of this chapter I want to consider Avicenna's second kind of knowledge, namely, the knowledge and acquisition of first principles and the role of sensory perception in acquiring these principles.

2 Acquiring First Principles

Like Aristotle before him, Avicenna claims that all demonstrative knowledge, that is, knowledge that involves intellectual (الذهني) teaching and learning, must proceed from prior knowledge (*Posterior Analytics* I 1; *Kitāb al-Burhān* I.3), namely,

knowledge that is not itself a product of a demonstration. The prior knowledge Avicenna has in mind is the existence claims and definitions of a science (I.12). For example in the science of physics, the physicist begins with the knowledge that motion exists as well as a definition of motion. In addition, the physicist will initially have some operational definitions such as accounts of what is meant by 'place', 'time', 'the continuum', 'void' and the like, that is to say, those things either purportedly required if there is to be motion or the necessary accidents that follow upon there being motion. The physicist subsequently investigates and sees if anything in the world corresponds with these initial nominal definitions. This initial knowledge insofar as it makes up the first principles of a given science is not demonstrated within the science itself—though in some cases it may be demonstrated in a 'higher science' (في علم قبله أو معه)—but either must be accepted if any science is to proceed at all or if the special science is to proceed, in the latter case it is one of the science's posits (وضع) (I.12, 58.14–17; 110.13–15).

Avicenna frequently states in *Kitāb al-Burhān* that a discussion of how the first principles of a science are acquired belongs to the subject of psychology (علم النفس); for an account of how we acquire first principles for Avicenna ultimately involves describing the various psychological and cognitive processes involved in human thought as well as any natural posits required to explain what we as human cognizers in fact do. Indeed, scholars working on Avicenna's psychology, such as Dimitri Gutas, Dag Hasse and Peter Adamson, to mention just three, have greatly advanced our understanding of such Avicennan cognitive processes as intuition or intellectual insight (الحدس),[22] abstraction (التجريد) and discursive thought (الفكر).[23] It is not my intent here to delve into Avicenna's psychological works, but hopefully to augment what he says in those works with comments he makes in *Kitāb al-Burhān*, particularly with respect to his empiricism and the roles of abstraction, induction (الاستقراء) and methodic experience (التجربة).[24]

In *Kitāb al-Burhān*, Avicenna exhibits a strong empiricist leaning in his account of how one acquires the first principles of a special science or of science in general, which is radically opposed to any theory of *a priori* or innate knowledge. This empirical element, especially with respect to the natural sciences, in seen most clearly in the comments that he makes at III.5, where he discusses Aristotle's claim that "if a certain sense is wanting, then necessarily a certain knowledge is also wanting" (*Posterior Analytics* I 18, 81a38–39). In basic agreement, Avicenna comments Aristotle:

> It is said, 'Whoever loses a certain sense, necessarily loses a certain knowledge,' which is to say that one cannot arrive at the knowledge to which that sense leads the soul. That is because the starting points from which one arrives at certain knowledge are demonstration and induction, that is, essential induction. Inevitably induction relies on sensory perception, while the universal premises of demonstration and their principles are obtained only through sensory perception, by acquiring the *phantasmata* (خيالات) of the singular terms through the intermediacy of [sensory perception] in order that the intellectual faculty freely acts on them in such a way that it leads to acquiring the universals as singular terms and combining them into a well-formed statement. If one wants to explain these [principles] to someone who is heedless of them (and there is no more suitable way to draw attention to them), then it can only be through an induction that relies on sensory perception. This follows because [the principles] are primitive and cannot be demonstrated, as for instance, the mathematical

> premises taken in proving that the Earth is at the center [of the universe], and the natural premises taken in proving that earth is heavy and fire light. That is why the principles of the essential accidents of every subject are learned first through sensory perception. Then from the sensibles some other intelligible is acquired, for example, the triangle, plane and the like in geometry, regardless of whether they are separable or inseparable. Indeed, then, the ways to arrive at them are initially through sensory perception (III.5, 158.11–159.3; 220.5–15).

Avicenna freely admits that the above is merely a concise statement and that the details will need to be worked out in the science of psychology. Fortunately, Avicenna also quickly sketches out those details in the remainder of III.5.

Thus Avicenna begins, "Something of the intelligible is not sensible, and something of the sensible inasmuch as it is what presents itself to sensory perception is not intelligible, namely, what presents itself for the apprehension of the intellect, even if sensory perception is a given starting point for acquiring much of the intelligible." Avicenna claims here that the objects of science, though starting from sensory perception, cannot be reduced simply to the perceptibles; rather, the objects of science are the intelligibles, which, though derived from the sensibles, are not identical with them.

To make his point, he has one consider a perceptible human, for example, Zayd or Omar, and the intelligible human, namely, what is common to Zayd and Omar that makes them both fall under the kind human. The perceptible human only presents itself to the senses as having a determinate magnitude, qualities, position, place and the like, all features that in some sense are unique to the individual at the time he is being perceived. In contrast, the intelligible human is something common to all humans, and as such is related to Zayd in the exact same way it is related to Omar as well as any other human. Indeed, Avicenna claims that the intelligible human is related to all instances of human "by way of absolute univocity" (بالتواطؤ المطلق). Thus, since what is sensibly perceived to belong to Zayd, Omar and other humans is not what is understood to belong to the form of humanity as it is found in the mind, Avicenna concludes that "the intelligible human is not what is conceived in the *phantasm* of the perceptible human" (III.5, 159.14–15; 121.8).

Since it is the intelligibles, or more exactly their definitions, that most frequently play the role of first principles in a science, it is necessary to see how the perceptibles are converted into intelligibles. Avicenna's answer is that this conversion takes place in part through the cognitive process of abstraction (التجريد).[25] Fortunately, Avicenna again outlines the most salient features of this psychological process.

> [T]he essences perceptible in existence are not in themselves intelligible, but perceptible; however, the intellect makes them so as to be intelligible, because it abstracts their true nature (حقيقتها) from the concomitants of matter. Still, conceptualizing the intelligibles is acquired only through the intermediacy of sensory perception in one way, namely that sensory perception takes the perceptible forms and presents them to the imaginative faculty, and so those forms become subjects of our speculative intellect's activity, and thus there are numerous forms there taken from the perceptible humans. The intellect, then, finds them varying in accidents such as it finds Zayd particularized by a certain color, external appearance, ordering of the limbs and the like, while it finds Omar particularized by other [accidents] different from those. Thus [the speculative intellect] receives these

> accidents, but then it extracts them, as if it is peeling away these accidents and setting them to one side, until it arrives at the account in which [humans] are common and in which there is no variation and so acquires knowledge of them and conceptualizes them. The first thing that [the intellect] inquires into is the confused mixture in the *phantasm*; for it finds accidental and essential features, and among the accidents those which are necessary and those which are not. It then isolates one account after another of the numerous ones mixed together in the *phantasm*, following them along to the essence [of human] (III.5, 160.7–17; 222.1–11).

This, then, is Avicenna's theory of abstraction in a nutshell.

Avicenna's language of 'extracting' (ينزع) and 'peeling away'(يقشر) may give the appearance that the intellect undertakes some mysterious process of 'dematerializing' or 'eliminating' certain features in the *phantasm* when it abstracts the intelligible. I believe that what Avicenna has in mind is actually simpler and more commonplace; for one can augment Avicenna's account here with comments that he makes about abstraction in his *Physics*, where one sees that far from being anything mysterious, much of the abstractive process is simply a matter of selective attention.

> Analysis (التحليل)[26] is to mark a distinction owing to things whose existence truly is in the composite; however, they are mixed in the view of the intellect. Thus some of them are separated from others through their potency and definition, or some of them indicate the existence of something. So, when [the intellect] closely attends to (تأمّل) the state of some of them, it moves from it to another (Avicenna (1983, II.9, 142.4–6)).

'Analysis', which Avicenna is treating very much like abstraction in the present passage, at least in part simply involves the far from mysterious process of selectively attending to certain features of the *phantasm*, that is, the sensible object as it appears in the intellect, to the exclusion of other features.

Clearly, this is not Avicenna's whole story concerning abstraction and acquiring first principles; for as he says later, acquisition of the first principles also involves "a conjunction of the intellect with a light emanated upon the soul and nature from the agent that is called the 'Active Intellect', that is, something leading the soul in potency to actuality. Be that as it may, sensory perception is a starting point, beginning with the accident, not the essence, of what [the intellect] has" (III.5, 161.6–8; 223.3–5). Admittedly, talk of 'emanation' and a separate 'Active Intellect' may sound peculiar, even mysterious, to modern ears. In fact, however, Avicenna's appeal to the Active Intellect is part and parcel of his naturalism and is well-integrated into both his physics and psychology; for in physics Avicenna would appeal to the Active Intellect to explain in part the acquisition of a new material form during substantial change, and analogously in psychology the acquisition of an intelligible form.[27] Avicenna's appeal to the Active Intellect in both cases, then, might be seen as an inference to the best explanation. He simply puts forth a natural posit needed to explain certain physical phenomena. In this respect Avicenna's positing the Active Intellect is loosely on par with Newton's initially positing his three laws and the concept of universal gravitation.[28] Although Newton could not demonstrate these aspects of his physics, if one granted them to him, he could explain a whole range of natural phenomena. The case is similar for Avicenna, and though we today do not accept Avicenna's explanation, before we congratulate

ourselves for having more advanced views than Avicenna, it should be noted that psychologists and cognitive scientists are still far from explaining the phenomena that Avicenna was addressing, namely, how mental states are generated from physical states and how thinking actually takes place. One can hardly fault Avicenna for not adequately explaining in terms that we today would prefer what we ourselves have not yet fully explained.

Let me be clear: I am not belittling the role that Avicenna finds for the Active Intellect in human cognition, but merely emphasizing another aspect of this phenomenon, which until recently has not been given its proper due. Abstraction, which begins with sensory perception, strips away one set of accidents, namely, those that follow on matter, and so prepares the way for the application of a new set of accidents, namely, the intelligible accidents, such as universality, that are acquired from the Active Intellect and are required if there is to be understanding. Both the roles of sensory perception and the Active Intellect are essential for a full account of Avicenna's view vis-à-vis human cognition.

In addition to abstraction, Avicenna lists three other ways that sensation is involved in acquiring the first principles of a science, or as Avicenna himself describes it, how "granting assent to the intelligibles is acquired through the senses" (III.5, 161.1–162.9; 222.17–224.8). These include (1) the particular syllogism (القياس الجزئي), (2) induction (الاستقراء) and (3) methodic experience (التجربة). Avicenna's comments concerning the particular syllogism are brief, consisting of two sentences.

> [T]he particular syllogism [involves] the intellect's having a certain universal generic judgment, and then the individuals of a species belonging to that genus are sensibly perceived. So the species form is conceptualized together with [the genus], and that judgment is then predicated of the species. In that case, then, an intelligible that was not [possessed] is acquired (III.5, 161.11–13; 223.8–10).

Since, this method requires one of the other three methods to explain the generic judgment presupposed by the particular syllogism, I shall keep my comments short. Imagine that one possesses some generic judgment, for example, all animals are mortal, or any other universal claim that can be predicated of the genus animal. Next, if the argument is not to be jejune, imagine that a biologist comes across something that he has never experienced before, and so has no knowledge about it, yet from sensory perception he recognizes that it is an animal. From this perception and his prior generic judgment concerning all animals, he can conclude that this newly discovered species of animal is also mortal and has whatever other properties follow upon being an animal in general.

The latter two empirical methods of acquiring knowledge of first principles, namely, induction and methodic experience, are far more interesting, and show Avicenna's unique development of Aristotelian themes as well as his departure from Aristotle.[29] Avicenna parts company with Aristotle in his overall attitude towards induction (or least how later Aristotelians understood induction) and is skeptical of the merit of induction as an adequate tool of science. At *Kitāb al-Burhān* III.5 he describes induction in the following lackluster terms:

> When the particular instances [of the first principle] are considered inductively, they call the intellect's attention to the belief of the universal; however, the induction that proceeds from sensory perception and the particulars in no way makes belief of a universal necessary, but only draws attention to it. For example, [when] two things both touch a third thing, but not each another, they require that that [third] thing is divisible. This aforementioned claim, however, may not be something established in the soul as well as it is sensibly perceived in its particular instances, which the intellect does notice and believes (III.5, 161.14–18; 223.11–15).

At most induction is merely a pointer (منبّه) that draws one's attention to the pertinent facts surrounding some state of affairs. Induction, then, does not make clear what the cause of that state of affairs is or even that there must be a cause. Although Avicenna's reservations towards induction might incline one to think that he is being anti-empirical, and so retarding science, such an assessment is far from the truth.

Earlier at *Kitāb al-Burhān* I.9 as well as in *Kitāb al-Qiyās* IX.22, Avicenna lays out what he finds problematic about induction. Induction has two elements: one involves the sensible content of induction and the other the rational structure of induction, namely, the syllogism associated with induction. If induction is to provide one with the necessary and certain first principles of a science, then the necessity and certainty of the conclusion of an inductive syllogism must be due either to induction's sensory element or its rational element or some combination of both. On the one hand, the purported necessity and certainty of induction cannot be known solely through induction's sensory element; for in good empirical fashion Avicenna recognizes that necessity and certainty are not direct objects of sensation. On the other hand, if the necessity and certainty are due to induction's rational component, then the syllogism associated with induction should not be question begging. Yet, complains Avicenna, in the scientifically interesting cases one of the premises of an induction will be better known than its conclusion, and so the induction is neither informative nor capable of making clear a first principle of a science.

At *Kitāb al-Qiyās* IX.22, Avicenna claims that induction in fact is successful in those cases where its divisions are exhaustive, as for example when animal is divided into mortal and immortal, or rational and irrational. The difficulty arises when one uses some other type of division that does not involve contradictory pairs. Unfortunately, Avicenna's discussion both in *Kitāb al-Qiyās* and *Kitāb al-Burhān* about the problematic type of division used in induction remains predominately in the abstract and the one concrete example he does provide—subsuming body and white under color—is singularly unhelpful. The following example, taken from Aristotle's *Prior Analytics* II 23, however, appears to be what he has in mind. Assume one divides long-lived animals into horses, oxen, humans and the like, and then one wants to use this premise to make clear inductively the cause of their longevity. Thus one might reason as follows:

1. all horses, oxen, humans and the like are gall-less (major premise);
2. long-lived animals are horses, oxen, humans and the like (minor premise);
3. therefore, long-lived animals are gall-less.

Avicenna's earlier point was that the induction works only if one can be certain that one has correctly identified all and only long-lived animals in the minor premise. One could be certain of this identification only if one knew what it is about this set of animals that guarantees that they and only they are the long-lived ones, but this knowledge would simply be to know the cause of these animals' longevity, the very premise one wanted to make clear. Thus it is not induction's rational element, at least in the scientifically interesting cases of induction, that explains the purported necessity and certainty of its conclusion.

Since necessity and certainty cannot be found in either induction's sensory or rational elements, it would be difficult to explain how it could emerge from the two taken jointly. Again, Avicenna is not dismissing induction out-right; it certainly has its place in science as a means of drawing one's attention to pertinent facts. Still, if induction is intended to establish the facts about some causal relation and so provide the first principle of a science, Avicenna contends that it simply fails.

Avicenna instead wants to replace induction with methodic experience, which like induction has both a sensory and rational, or syllogistic, component. Unlike induction, methodic experience does not purport to explain *what* the causal relation is between two terms of a first principle, but only to identify *that* there is a causal relation.

> [Methodic experience] is not like induction; for induction, in chancing upon the particulars, does not occasion universal certain knowledge, even if it might be something drawing attention [to it], whereas methodic experience does. Indeed, methodic experience is like the observer and perceiver seeing and sensing that certain things belong to a single kind upon which follows the occurrence of a given action or affection. So when that is repeated numerous times, the intellect judges that this is an essential feature belonging to this thing that is not some mere chance occurrence, since that which is by chance does not occur always. An example of this is our judgment that a magnet attracts iron, and that scammony purges bile (III.5, 161.20–162.3; 223.16–224.2).

In methodic experience, there is the regular observation that two things always occur together without any falsifying evidence to the contrary. Thus the scientist reasons that whenever two things always occur together without any falsifying instance there must be a cause relating those two things. One always observes a magnet's attracting iron, for example; therefore, there must be some causal relation between the magnet's attraction and the iron, otherwise it would not always occur. Methodic experience has not explained what this causal relation is, only that there is such a relation; nonetheless, the conclusions arrived at by methodic experience can still be used as first principles of a science in order to explain other phenomena.

It should be further noted that at *Kitāb al-Burhān* I.9, where Avicenna fully discusses methodic experience, he is quite insistent that the necessary knowledge obtained through it is only conditional (بشرط) and applies only to the domain under which the examination was made. "[Methodic experience] does not provide *absolute* universal syllogistic knowledge, but only *conditional* universal [knowledge], that is, this thing which is repeated to the senses adheres to its nature as an ongoing thing with respect to the domain in which it is repeated to the senses, unless

there is an obstacle. Thus [the knowledge] is universal with this condition, but not absolutely universal" (I.9, 46.20–23; 96.5–7). It is because knowledge of first principles acquired through methodic experience is limited to the domain under which the examination took place that Avicenna further warns the scientist that in light of new empirical data one may need to revise one's claims.

Thus he considers the case of the scientist who has repeatedly observed that on administering scammony there is always an accompanying purging of bile. The only thing that the observer can legitimately conclude, warns Avicenna, is that those varieties of scammony that he has tested always lead to this result; however, should new varieties of scammony become available that do not conform to the earlier findings, the initial hypothesis must be revised. Avicenna makes this point clearly:

> We also do not preclude that in some country a disposition (مزاج) and special attribute (خاصيّة) are associated with scammony not to purge (or there is absent in it a disposition and special attribute); however, it is necessary that our judgment based upon methodic experience is that the scammony commonplace to us and perceived [before us], either from its essence or from the nature in it, purges bile, unless it is opposed by an obstacle (I.9, 48.4–7; 97.12–14).

Here in Avicenna's account of methodic experience one sees perhaps the strongest piece of evidence for Avicenna's naturalism and empirical stance towards science, namely that scientific hypotheses in principle must be revisable in light of new empirical data.

To conclude by way of summary, Avicenna's naturalized epistemology involves two separate, but closely related aspects: (1) identifying the methods and tools of good science in the case of demonstrative knowledge and (2) describing the psychological processes by which one becomes aware of causal relations in the case of first principles. With respect to the first aspect we have seen that the scientific tools and methods are predominately logical tools; however, Avicenna does not envision logic as providing some means for rationally or logically reconstructing the world beginning solely with *a priori* knowledge perhaps mixed with sense data. Far from endorsing such a foundationalist project, Avicenna sees logic as providing an aid to discovering the rational, causal structure inherent in the world itself. As for the second aspect, I believe Avicenna would happily endorse W. V. O. Quine's position, "Epistemology, or something like it, simply falls into place as a chapter of psychology and hence of natural science. It studies a natural phenomenon, viz., a physical human subject" (Quine, 25).

Acknowledgments I would like to acknowledge the National Endowment for the Humanities, the University of Missouri Research Board and the Center for International Studies at the University of Missouri, St. Louis for their support of a research leave during which this project was undertaken. I would also like to thank David C. Reisman, Peter Adamson and Shahid Rahman for their acute remarks on an earlier version of this chapter. As always any faults are solely my own.

Notes

* I have consulted both Badawī's and 'Afīfī's editions of *Kitāb al-Burhān* [Avicenna (1966) and (1956) respectively]. References to *Kitāb al-Burhān* are to book and chapter, then page and line number of Badawī's edition followed by 'Afīfī's edition. In both cases line numbers have been introduced by myself for ease of reference. In those cases where I have preferred Afīfī's edition, I have marked the reference with a '*'.

1. For an alternative interpretation of Avicenna's theory of knowledge, which is more closely along traditional epistemological lines, see S. Nuseibeh (1989; 1996, 836–838). Nuseibeh argues that for Avicenna real knowledge is had only if it is verified. He then proceeds to argue that Avicenna held that there could neither be an empirical nor conceptual verification of any purported piece of knowledge, at least not prior to death, and thus Avicenna should rightly be described as a 'skeptic'. Nuseibeh's argument only holds if in fact Avicenna believed that science needed to be in some way verified or justified. In this chapter, I shall argue that Avicenna did not hold such a position.
2. My understanding of naturalized epistemology comes primarily from the following sources: W. V. O. Quine (1994), P. Kitcher (1992), H. Kornblith (1994) and P. Roth (1999) as well as through numerous discussions with Professor Roth.
3. M. E. Marmura (1990) provides a summary of some of the points in Avicenna's *Kitāb al-Burhān*.
4. I do not consider here the important cognitive process of حدس, since in *Kitāb al-Burhān* Avicenna has very little to say about it. Moreover, in this work حدس appears to be exclusively a means for acquiring demonstrative knowledge from already possessed prior knowledge; see *Kitāb al-Burhān* I.3, 13, 6–9; 59.11–13 and III.3, 192, 2–4. Admittedly, in Avicenna's psychological works حدس plays a more prominent role in acquiring first principles; see D. Gutas (1988, 159–176; 2001).
5. See J. Barnes (1975), P. Byrne (1997), M. Ferejohn (1991), R. McKirahan (1992) and W. Wians (1989).
6. This distinction is clearly implicit in Avicenna's writing (especially at I.8) and explicitly made by al-Fārābī (1987, 98–99), where he speaks of the certainty of a belief as being a 'congruence' or 'adequation' (المطابق) with the state of affairs in the world.
7. 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. See I.7, 31.11–18; 78.15–79.4.
8. Aristotle suggests this distinction at *Posterior Analytics* I 13, where he discusses the difference between understanding 'the fact that' (τὸ ὅτι) and 'the reason why' (τὸ διότι).
9. Studies on Avicenna's theory of causation include: M. E. Marmura (1984), R. Wisnovsky (2002) and A. Bertolacci (2002). For a discussion of causalities' role in relation to medieval Arabic metaphysics in general see T-A. Druart (2005).
10. Admittedly the argument I present is only implicit in Avicenna's text. Still, that the interpretation that I suggest is the way certain later thinkers understood Avicenna's argument is witnessed by al-Ghazālī's treatment of causation in his celebrated 17th Discussion of his *Tahāfut al-falāsifa*. There al-Ghazālī treats only the argument for necessary causal relation that I present, and says nothing about Avicenna's more well-known argument for this thesis from *Najāt* XI.2.iii.
11. It is possible that Galen introduced the relational syllogism as one of the possible demonstrations used in science in his now lost *De demonstratione*, of which large parts, though not the whole, were available in Arabic translation; see N. Rescher (1966, 4–6). Concerning Galen's theory of the relational syllogism see Galen (1964, ch. XVI).
12. For a discussion of Avicenna's metaphysics of relation see M.E. Marmura (1975, 83–99).

13. For an excellent survey of the term الإستثناء in Arabic logic see K. Gyekye (1972). For primary Avicennan sources concerning الإستثناء one may consult Avicenna (1964, VIII.1 and 2; 1971, 374) and the English translation of the former text by N. Shehaby (1973, 183–199).
14. Avicenna also considers the *reductio ad absurdum* (قياس الخلف), but his comments are brief, since he believes that this mode of argument can be converted into a demonstration *quia* (III.8, 42.7–8; 90.15–17).
15. See Aristotle, *Posterior Analytics* II 2 and Avicenna, *Kitāb al-Burhān* I.8.
16. For a discussion of Avicenna's conception of 'thingness' see R. Wisnovsky (2000; 2003, ch. 8). For a more general discussion of Avicenna's conception of the 'essence considered in itself' see M. E. Marmura (1979; 1992); and for a more specific discussion of the relation of essences considered in themselves to logic and science see J. McGinnis (2007).
17. For an alternative interpretation of Carnap's *Der logische Aufbau der Welt*, and I believe a more philosophically satisfying one, see M. Friedman (1992).
18. Avicenna makes this point explicitly at the end of his *Physics*, where he argue against what we might call a 'mathematized physics'; see Avicenna (1983, IV.15, 331.7–333.9).
19. For a more complex example that is actually taken from Avicenna's *Physics* see J. McGinnis (2007, section IV).
20. The logical reason is that the distribution of either the minor or middle term will not extend far enough.
21. The logical explanation is that the middle term will not connect the two terms.
22. Neither 'intuition' nor 'insight' properly captures the sense of حدس, which more correctly is a quick, though clean, heuristic by means of which one correctly identifies the middle term of a syllogism.
23. See D. Gutas (1988, 159–176; 2001), D. Hasse (2001) and P. Adamson (2004).
24. For a discussion of Avicenna's empirical methodology, and, more specifically, medieval Arabic physicians' empirical attitude in relation to medicine see D. Gutas (2003). Similar ground is covered, albeit with the intent of showing that Avicenna was a skeptic, in S. Nuseibeh (1981). Both Gutas and Nuseibeh—Nuseibeh explicitly and Gutas only implicitly and with certain qualifications—suggest that for Avicenna the empirical findings of the physician cannot be used to discover, formulate or correct the first principles of medicine, since these principles are given in the higher science of physics. There is a sense in which this claim is true, namely, insofar as Avicenna is banning the majority of the physicians from undertaking this task; however, this proscription is due to the fact that most of these physicians lack a thorough knowledge of physics, which is required for such a task. In principle, however, it seems that Avicenna need not preclude one well-versed in both medicine and physics from using the empirical data acquired in medicine to inform one's understanding of medicine's first principles, provided that the physician-physicist is approaching that data *qua* physicist.
25. For discussions of abstraction that emphasize the role of the Active Intellect as opposed to the role of the human intellect and sensory perception see the following: H. Davidson (1992, ch. 4), F. Jabre (1984) and S. Nuseibeh (1989). Nuseibeh reduces حدس to inspiration and revelation that is emanated by the Active Intellect and in fact he seems to eliminate abstraction altogether from Avicenna's theory of concept formation. For a more recent account of abstraction that emphasizes the role of the human intellect in abstraction and is overall consonant with Avicenna's comments in *Kitāb al-Burhān* see D. Hasse (2001).
26. Although the term used in the context of the *Physics* is not التجريد or التجرُّد, but التحليل, this in part seems to be a concession to the text upon which Avicenna is commenting, namely, John Philoponus' *Physics* commentary. In its proper technical usage التحليل means 'analysis', that is, a breaking down of a thing into its constitutive parts for the purposes of investigation or definition. Still, Avicenna's context makes it clear that he is considering التحليل as at least closely akin to abstraction; for he is addressing the issue of how one ultimately acquires the concepts of 'matter' and 'form', which indeed are first principles in physics. Moreover, even in Avicenna's psychological works he does not use التجريد exclusively for 'abstraction';

rather, he uses a whole complex of terms, such as انتزع, أفرز, and of course جرّد. This list, I thus suggest, might also in certain cases include حلل.

27. In Avicenna's psychology the Active Intellect also plays the further role of providing the storehouse for the intelligibles when they are not being thought by humans, and so allows Avicenna to avoid positing that the intelligibles subsist on their own in some Platonic realm of the Forms.
28. Indeed when Newton's *Principia* first appeared he was criticized for his concept of universal gravitation by no less than Huygens for backsliding and introducing scholastic occult qualities; see R. Westfall (1971, 155-159).
29. For a detailed discussion of Avicenna on induction and methodic experience see J. McGinnis (2003) (it should be noted that there I translated التجربة as 'experimentation', whereas I now believe that 'methodic experience' more properly captures the sense of the Arabic); also see J. L. Janssens (2004), which in important ways supplements and corrects my earlier work.

References

Adamson, P.: 2004, "Non-Discursive Thought in Avicenna's Commentary on the *Theology of Aristotle*" in J. McGinnis (ed.), *Interpreting Avicenna: Science and Philosophy in Medieval Islam*, Islamic Philosophy, Theology and Science, Text and Studies, vol. 56, Brill, Leiden, pp. 87–111.

Aristotle: 1949, *Aristotle's Prior and Posterior Analytics*, ed. W. D. Ross, Clarendon Press, Oxford.

Avicenna: 1952, *al-Madkhal*, ed. T. Hussein, Publication du Minsistère de l'Instruction Publique (Culture Générale), Cairo.

Avicenna: 1956, *Kitāb al-Burhān*, ed. A. E. ʿAfīfī, The General Egyptian Book Organization, Cairo.

Avicenna: 1964, *Kitāb al-Qiyās*, ed. S. Zāyed, Ministère de la culture, Cairo.

Avicenna: 1966, *Kitāb al-Burhān*, ed. ʿA. R. Badawī, 2nd edn., Association of Authorship, Translation & Publication Press, Cairo.

Avicenna: 1971, *al-Ishārāt wa-t-tanbīhāt*, ed. S. Dunyā, Dār al-Maʿārif, Cairo.

Avicenna: 1983, *Kitāb aṭ-Ṭabīʿīyāt*, *as-samāʿ aṭ- ṭabīʿī*, ed. S. Zāyed, The General Egyptian Book Organization, Cairo.

Avicenna: 1985, *Kitāb an-Najāt*, ed. M. T. Dānishpazhūh, Intishārāt-i Dānishgāh-yi Tihrān, 1863, Dānishgāh-yi Tihrān, Tehran.

Barnes, J: 1975, "Aristotle's Theory of Demonstration" in J. Barnes, M. Schofield and R. Sorabji, (eds.), *Articles on Aristotle: 1*, *Science*, Duckworth, London, pp. 65–87.

Bertolacci, A.: 2002, "The Doctrine of Material and Formal Causality in the *Ilāhiyyāt* of Avicenna's *Kitāb al-Shifāʾ*", *Quaestio* **2**, 125–154.

Black, D. L.: 1993, "Estimation (*Wahm*) in Avicenna: The Logical and Psychological Dimensions", *Dialogue* **32**, 219–258.

Byrne, P: 1997, *Analysis and Science in Aristotle*, State University of New York Press, Albany, NY.

Davidson, H.: 1992, *Alfarabi, Avicenna, and Averroes, on Intellect*, Oxford University Press, Oxford.

Druart, T.-A.: 2005, "Metaphysics" in P. Adamson and R. C. Taylor (eds.), *The Cambridge Companion to Arabic Philosophy*, Cambridge University Press, Cambridge, UK, pp. 327–348.

Al-Fārābī: 1987, *Kitāb Sharāʾiṭ al-yaqīn*, M. Fakhry ed., Dār al-Mashriq, Beirut, pp. 97–104.

Ferejohn, M.: 1991, *The Origins of Aristotelian Science*, Yale University Press, New Haven, CT.

Friedman, M.: 1992, "Epistemology in the *Aufbau*", *Synthese* **93**, 15–57.

Galen: 1964, *Institutio Logica*, trans. J. S. Keiffer, The Johns Hopkins Press, Baltimore, MD.

Al-Ghazālī: 1997, *Tahāfut al-falāsifa*, edited and translated by M. E. Marmura, Islamic Translation Series, Brigham Young University Press, Provo, UT.

Gutas, D.: 1988, *Avicenna and the Aristotelian Tradition, Introduction to Reading Avicenna's Philosophical Works*, Islamic Philosophy and Science, Texts and Studies, vol. 4, Brill, Leiden.

Gutas, D.: 2001, "Intuition and Thinking: The Evolving Structure of Avicenna's Epistemology" in R. Wisnovsky (ed.), *Aspects of Avicenna*, Markus Wiener Publishers, Princeton, NJ, pp. 1–38.

Gutas, D.: 2003, "Medical Theory and Scientific Method in the Age of Avicenna" in D. C. Reisman (ed.), *Before and After Avicenna: Proceedings of the First Conference of the Avicenna Study Group*, Islamic Philosophy, Theology and Science, Text and Studies, vol. 52, Brill, Leiden, pp. 145–162.

Gyekye, K.: 1972, "The Term *Istithnā'* in Arabic Logic", *Journal of the American Oriental Society* **92**, 88–92.

Hasse, D.: 2001, "Avicenna on Abstraction" in R. Wisnovsky (ed.), *Aspects of Avicenna*, Markus Wiener Publishers, Princeton, NJ, pp. 39–72.

Jabre, F.: 1984, "Le sens de l'abstraction chez Avicenne", *Mélanges de l'Université St. Joseph de Beyrouth* **50**, 281–310.

Janssens, J. L.: 2004, "'Experience' (*tajriba*) in Classical Arabic Philosophy (al-Fārābī – Avicenna)", *Quaestio* **4**, 45–62.

Kitcher, P.: 1992, "The Naturalists Return", *The Philosophical Review* **101**, 53–114.

Kornblith, H.: 1994, "Introduction: What is Naturalistic Epistemology" in H. Kornblith (ed.), *Naturalizing Epistemology*, 2nd edn., The MIT Press, Cambridge, MA, pp. 1–14.

Marmura, M. E.: 1975, "Avicenna's Chapter 'On the Relative' in the *Metaphysics* of the *al-Shifā"*" in G. F. Hourani (ed.), *Essays on Islamic Philosophy and Science*, Studies in Islamic Philosophy and Science, State University of New York Press, Albany, NY, pp. 83–99.

Marmura, M. E.: 1979, "Avicenna's Chapter on Universals in the *Isagoge* of his *al-Shifā"*" in A. T. Welch and P. Cachia (eds.), *Islam Past and Present Challenges: Studies in Honour of W. M. Watt*, Edinburgh University Press, Edinburgh, pp. 34–56.

Marmura, M. E.: 1984, "The Metaphysics of Efficient Causality in Avicenna (Ibn Sina)" in M. E. Marmura (ed.), *Islamic Theology and Philosophy: Studies in Honor of George F. Hourani*, State University of New York Press, Albany, NY, pp. 172–187.

Marmura, M. E.: 1990, "The Fortuna of the *Posterior Analytics* in the Arabic Middle Ages" in M. Asztalos, J. Murdoch, I. Niiniluoto (eds.), *Knowledge and the Sciences in Medieval Philosophy, Proceedings of the Eighth International Congress of Medieval Philosophy (S.I.E.P.M), Helsinki 24–29 August 1987*, Acta Philosophica Fennica, vol. 48, Yliopistopaino, Helsinki, pp. 85–103.

Marmura, M. E.: 1992, "Quiddity and Universality in Avicenna," in P. Morewedge (ed.), *Neoplatonism and Islamic thought*, Studies in Neoplatonism, vol. 5, State University of New York, Albany, NY, pp. 77–87.

McGinnis, J.: 2003, "Scientific Methodologies in Medieval Islam", *Journal of the History of Philosophy* **41**, 307–327.

McGinnis, J.: 2007, "Logic and Science: The Role of the Genus and Difference in Avicenna's Logic, Science and Natural Philosophy" in F. Del Punta (ed.), *Documenti e Studi*, special issue dedicated to universals.

McKirahan, R.: 1992, *Principles and Proofs: Aristotle's Theory of Demonstrative Science*, Princeton University Press, Princeton, NJ.

Nuseibeh, S.: 1981, "Avicenna: Medicine and Scepticism", *Koroth* **8**$_{1\text{-}2}$, 9–20.

Nuseibeh: 1989, "Al-'Aql al-Qudsī: Avicenna's Subjective Theory of Knowledge", *Studia Islamica* **69**, 39–54.

Nuseibeh: 1996, "Epistemology" in S. H. Nasr and O. Leaman (eds.), *History of Islamic Philosophy*, Routledge History of World Philosophies, vol. 1, Routledge, London and New York, ch. 49.

Quine, W. V. O.: 1994, "Epistemology Naturalized" reprinted in H. Kornblith (ed.), *Naturalizing Epistemology*, 2ed, The MIT Press, Cambridge, MA, pp. 15–31.

Rescher, N.: 1966, *Galen and the Syllogism*, University of Pittsburgh Press, Pittsburgh, PA.

Roth, P.: 1999, "The Epistemology of 'Epistemology Naturalized'", *Dialectica* **53**, 89–109.

Shehaby, N.: 1973, *The Propositional Logic of Avicenna*, D. Reidel Publishing Co., Dordrecht-Holland.
Westfall, R.: 1971, *The Construction of Modern Science: Mechanism and Mechanics*, John Wiley & Sons, Inc., New York.
Wians, W.: 1989, "Aristotle, Demonstration and Teaching", *Ancient Philosophy* **10**, 245–253.
Wisnovsky, R.: 2002, "Final and Efficient Causality in Avicenna's Cosmology and Theology", *Quaestio* **2**, 97–123.
Wisnovsky, R.: 2000, "Notes on Avicenna's Concept of Thingness (*Shay'iyya*)", *Arabic Sciences and Philosophy* **10**, 181–221.
Wisnovsky, R.: 2003, *Avicenna's Metaphysics in Context*, Cornell University Press, Ithaca, NY.