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Logic and Science : The Role of Genus and Difference in Avicenna's Logic, Science and Natural Philosophy*

What is the relation between logic and science ? One answer that comes to mind is that logic provides a language, or perhaps better a syntax, for modeling scientific discourse. Avicenna himself seems to have believed as much, when he writes, « The relation of this field of study [i.e., logic] to inner reflection, which is called 'internal reasoning' is like the relation of grammar to the explicit interpretation, which is called 'external reasoning', and like the relation of prosody to the poem »¹. In this respect, Avicenna notes, logic is a tool (*āla*) that guarantees a certain precision in scientific reasoning and even safeguards science against the introduction of hidden assumptions and formal fallacies. There is a deeper question, however, concerning the relation between logic and science as well : What is the relation between the objects of logic, namely, the universal predicables, which at least for Avicenna are purely mental objects, and the objects of science, namely, the things in the world and their causal interactions, which for Avicenna are purely extra-mental objects ?² In other words, what is it that ensures that objects that exist only in the mental world map onto objects that exist only in the external world ? What bridges the gap between these two worlds ? Avicenna is a scientific realist inasmuch as for him the goal of science is ultimately a type of necessary certainty about the way the world is³. Thus, if one cannot be

* I would like to thank Peter Adamson for his invaluable comments on an earlier version of this paper. I would also like to acknowledge the generous support for this project made available by a National Endowments for the Humanities Fellowship and the Institute for Advanced Study.

¹ AVICENNA, *ash-Shifā'*, *al-Mantiq*, vol. I, *Madkhal*, I.3, p. 20 Madkūr.

² Superficially this question appears to be the problem of the external world and the issue of whether it is even possible to have knowledge of the external world ; for if what is immediately known to us is only mental objects, what justification is there that extra-mental objects correspond with our mental objects, or even more strongly, what justifies that there is anything except the mental ? In general, Avicenna seems to have very little patience for skeptical questions such as this one. For Avicenna we simply do have knowledge of the external world. Thus the important question for Avicenna is not whether knowledge of the external world is possible, but what is the explanation of the fact that we do have knowledge of the external world.

³ Although ideally for Avicenna the necessary certainty is absolute necessary certainty, he also allows, and counts as genuinely scientific, conditional necessary certainty. See J. MCGINNIS, *Scientific Methodologies in Medieval Islam : Induction and Experimentation in the Philosophy of*

certain that the objects of logic and the conclusions derived from logic actually capture the way the world really is, then logic, for all the precision in reasoning it might bring, would fail to be an adequate tool for doing science, at least to Avicenna's mind. If logic is to play a role in the scientific enterprise, as Avicenna believes that it does, then there must be some bridge, or common element, linking the universal predicables treated in logic with the concrete particulars that make up the world that the sciences attempt to explain.

Michael Marmura in two articles — « Avicenna's Chapter on Universals in the *Isagoge* of his *Shifā'* »⁴ and « Quiddity and Universality in Avicenna »⁵ — has done much to provide a foundation for explaining how Avicenna thought that the notion of the quiddity or essence in itself could function as the bridge or common element shared by both universal predicables and concrete particulars. His analyses are based on Avicenna's discussion of the genus in the *Madkhal*, the work most closely paralleling Porphyry's *Eisagōgē*^a. Whereas Marmura was primarily concerned with Avicenna's theory of universals *per se*, I want to focus on how Avicenna's theory provides an answer to our initial question, namely, « What is the relation between logic and science? ». In addition, I want to augment Marmura's treatment of Avicenna's account of universal predicables by considering not only Avicenna's discussion of the genus in the *Madkhal*, but also his discussion of the difference. Furthermore, I want to supplement Avicenna's account in the *Madkhal* by considering his discussions of the genus and difference and their roles in science as he presents them in passages from his *Kitāb al-Burhān* (*The Book of Demonstration*, which most closely corresponds with Aristotle's *Posterior Analytics*)⁶. Finally, I consider how Avicenna applies the theoretical considerations developed in these works to a practical physical problem treated in his *Kitāb at-Ṭabī'iyāt*, or *Physics*, where seeing how Avicenna uses logic in the process of scientific discovery itself illuminates Avicenna's own understanding of logic's relation to science⁷.

Ibn Sīnā, « Journal of the History of Philosophy », 41, 2003, pp. 307-327 ; and J. L. JANSSENS, 'Experience' (tajriba) in *Classical Arabic Philosophy (al-Fārābī - Avicenna)*, « Quaestio », 4, 2004, pp. 45-62, which in important ways supplements and corrects my earlier work.

⁴ In M. E. MARMURA, *Probing in Islamic Philosophy. Studies in the Philosophies of Ibn Sina, al-Ghazali and Other Major Muslim Thinkers*, Global Academic Publishing, Binghamton, NY 2005, pp. 33-59 ; originally published in A. T. WELCH, P. CACHIA eds., *Islam Past and Present Challenges : Studies in Honour of W. M. Watt*, Edinburgh University Press, Edinburgh 1979, pp. 34-56.

⁵ In MARMURA, *Probing in Islamic Philosophy* cit., pp. 61-70 ; originally published in P. MOREWEDGE ed., *Neoplatonism and Islamic thought*, State University of New York, Albany, NY 1992 (Studies in Neoplatonism, 5), pp. 77-87.

⁶ AVICENNA, *ash-Shifā', al-Manṭiq, Kitāb al-Burhān* Badawī.

⁷ AVICENNA, *ash-Shifā', at-Ṭabī'iyāt*, vol. I, *as-Samā' at-ṭabī'i* S. Zāyed.

I

Before I begin, however, I should briefly explain and motivate the central contrast that I find in the thought of Avicenna, namely, between logic and science. In the *Madkhal*, Avicenna, following al-Fārābī⁸, distinguishes two aspects that are involved in knowing something scientifically (‘*alima, ya ‘ilamu, ‘ilm*’)⁹. These are *at-taṣawwur* and *at-taṣdīq*, which we might tentatively translate as ‘conceptualization’ and ‘truth making’ respectively¹⁰. Conceptualization simply involves understanding the meaning or sense (*ma‘nā*) of a word or a statement or even how statements work together to form an inference, with no reference to whether that term refers, or the statement is true or the inference is sound. He clarifies his point further by adding that conceptualization involves the form of a statement and its components occurring in the mind. Truth making involves not only knowing the meaning or form of a word, statement or inference occurring in the mind, but also in addition « that the relation of this form to the things themselves occurs in the mind, namely that [the things in themselves] map onto (*muṭābiqa*) [the form in the mind] »¹¹. Bearing Avicenna’s distinction between conceptualization and truth making in mind, when I speak of ‘logic’ and the ‘objects of logic’, such as genus, difference and species, I mean that aspect of knowledge that concerns conceptualization and the objects of conceptualization, whereas when I speak of ‘science’ and ‘the objects of science’, such as extra-mental things and their causal relations, I mean, primarily¹², that aspect of knowledge that involves truth making and the truth makers.

Let us now turn to the topic at hand, namely, what relates logic and science. In the *Madkhal* Avicenna makes the at first seemingly paradoxical claim that « the animal in itself is a certain thing (*ma‘nā*) — whether as something existing in concrete particulars or as something conceptualized (*mutaṣawwir*) in the soul — but in itself is neither general nor particular

⁸ AL-FĀRĀBĪ, *Kitāb al-Burhān wa-kitāb sharā‘ al-yaqīn*, pp. 20-22 Fakhry ; for a discussion of the structure of al-Fārābī’s text see D. L. BLACK, *Knowledge (‘ilm) and Certitude (yaqīn) in al-Fārābī’s Epistemology*, « Arabic Sciences and Philosophy », 16, 2006, pp. 11-45.

⁹ AVICENNA, *Madkhal* ed. cit., I.3. p. 17.7.

¹⁰ I have preferred ‘truth making’ as a translation of *taṣdīq* over other current translations, such as ‘affirmation’ or ‘verification’, for two reasons. First, it brings out the root meaning of the verb, namely, ‘to be true’. Second, ‘affirmation’ and ‘verification’ are frequently associated, at least among contemporary philosophers of science, with the positivists’ program in philosophy of science, but Avicenna is no proto-positivist.

¹¹ AVICENNA, *Madkhal* ed. cit., I.3, p. 17.16-17.

¹² I say ‘primarily’, because truth making clearly presupposes conceptualization for Avicenna, whereas my focus is on what in the world makes the conceptualization in the mind true.

(*khāṣṣ*) »¹³. The claim harkens us back to distinctions Avicenna drew earlier in the *Madkhal* concerning (1) the essence as it is considered in itself, (2) that essence considered as something existing in extra-mental material things and (3) that essence considered as existing in the mind.

« The essences (*māhīyāt*) of things might be in the concrete particulars of the things and in the conceptualization (*at-taṣawwur*), and so they can be considered in three ways. [One] is the consideration of the essence inasmuch as it is that essence without being related to one of the two [ways] of existence [i.e., either concerning the concrete particulars or concerning conceptualization] and whatever follows upon it insofar as it is such. [Two] it can be considered insofar as it concerns concrete particulars, in which case certain accidents that particularize its existing as that follow upon it. [Three] it can be considered insofar as it concerns conceptualization, in which case certain accidents that particularize its existing as that follow upon it, as, for example, positing and predication, and universality and particularity, as well as the essential and accidental in predication »¹⁴.

As the essence in itself exists in external, concrete things it is made particular by the accidents that follow on its being in matter, while as existing mentally it is made universal by the accidents that follow upon its being in the intellect; however, considered in itself, the essence is neither particular nor general. This essence or quiddity in itself is potentially¹⁵ either something material, and so a concrete particular, or something immaterial, that is, mental, and so a universal, but in itself it is neither.

Avicenna has two reasons for claiming that the essence considered in itself is essentially neither general nor particular, neither something essentially existing in concrete particulars nor something essentially existing in the mind. One reason is negative, the other is positive. The negative and immediate reason Avicenna relates is that it allows one to avoid a dilemma that faces anyone who makes the essence considered in itself either general or particular. The positive and broader reason, which admittedly Avicenna does not make immediately explicit, is that it allows him an answer to our initial question, namely, « What is the relation between the objects of science and the objects of logic ? ».

¹³ AVICENNA, *Madkhal* ed. cit., I.12, p. 65.11-12.

¹⁴ *Ibid.*, I.2, p. 15.1-6.

¹⁵ Avicenna in fact says that the quiddity is akin to wood, one of his common tropes indicating the material cause (*ibid.*, I.12, 66.8-9). See J. MCGINNIS, *The Avicennan Sources for Aquinas on Being: Supplemental Remarks to Brian Davies' 'Kenny on Aquinas on Being'*, « The Modern Schoolman », 82/2, 2005, pp. 131-142.

Avicenna presents the immediate and negative reason in the form of a dilemma :

« If [the animal] in itself were general — so that animality is general because it is animality — then necessarily no animal is an individual ; rather every animal is something general. Again, if the animal — because it is an animal — were an individual, then only a single individual [animal] would be possible, namely, that animal that animality requires and it would be impossible that any other thing is an animal »¹⁶.

The first horn assumes that animal is something essentially general. In other words, animal in itself is the animality common to many animals. As such being an animal must only apply to many animals, and so paradoxically it could not apply to any animal taken singularly. In other words, given the assumption that animal in itself necessarily and essentially only holds of many animals, and no animal taken individually is many animals, no individual animal could essentially be an animal. In this case our world would be something like the Platonic realm of the Form *sans* the Realm of Becoming, and whatever else one might want to say about such a world, it is surely not the concrete world we live in. The second horn assumes that the animal in itself is essentially particular and as such is not applicable to many, just as the individual Socrates is not applicable to many. As such being an animal must apply only to a single individual and anything other than that individual would essentially not be an animal. In this case, every genus (or perhaps species) in our world could only be populated by a single member, and again whatever else one might want to say about such a world, it is not the world we live in. Therefore, concludes Avicenna, to make the animal in itself either general or particular leads to absurd consequences, and thus animal in itself cannot be either general or particular.

One might complain that the dilemma only arises when one assumes that there are essences considered in themselves that are different than either the essences as they exist in concrete particulars or in the mind¹⁷. Thus one might argue that essences first exist in concrete particulars, and then after a process of abstraction exist in the mind, but in themselves they do not exist.

¹⁶ AVICENNA, *Madkhal* ed. cit., I.12, p. 65.12-16.

¹⁷ The line of objection presented below has been argued by both Averroes and Etienne Gilson. See AVERROES, *Tahāfut at-tahāfut*, 3d ed., Disp., V, pp. 302, 29-305, 34 and Disp. VII, 369, 3-373, 11 M. Bouyges ; *Averroes' Tahafut al-Tahafut*, tran. S. VAN DEN BERGH, 2 vols., Oxford University Press, Oxford 1954, vol. I, pp. 302, 1-305, 5 and 369, 1-373, 9 ; and E. GILSON, *Being and Some Philosophers*, Pontifical Institute of Mediaeval Studies, Toronto 1952, pp. 75-76.

Consequently, the complaint might continue, Avicenna has simply succumbed to a psychological illusion, namely, he has assumed some *tertium quid* that is distinct from the essences in concrete particulars and the essences in the intellect. Thus Avicenna has been misled into thinking that the purported essences in themselves have some quasi-existence common to both extra-mental and mental objects¹⁸. In reality, our objector might conclude, only essences in concrete particulars and in the intellect are required. In short, one might think that Avicenna has unnecessarily bloated his ontology by claiming that there is something that is neither general nor particular.

First, as a point of clarification, as I understand Avicenna he is not claiming that the essence considered in itself ever actually exists as something neither particular nor general, neither in a body nor in the soul; rather, I maintain, he is claiming that existing in the body or in the intellect are different descriptions of the essence in itself, neither one of which necessarily and essentially belongs to the essence in itself. So, for example, I, as a material thing, am not necessarily and essentially a standing thing or a sitting thing or a lying thing, although I, as a human, necessarily and actually exist (at different times) as something standing, sitting or lying. The difference is that between 'x is F' and 'x as F'. Avicenna, if I am correct, then, is not claiming that the essence in itself *is* some existing thing to which there is superadded different modes of existence, whether existence in concrete particulars or existence in the mind; rather, the essence in itself exists either *as* something in concrete particulars or *as* something in the intellect.

It is because the essence in itself is something common to both concrete particulars and mental objects that Avicenna can explain the demonstrative character of science. Here we arrive at the second positive reason mentioned above for claiming that the essence considered in itself is essentially neither general nor particular, neither something essentially existing in concrete particulars nor something essentially existing in the mind. This thesis, in fact, provides Avicenna the means to explain the relation between the objects of logic and the objects of science. First, the objects of logic, that is, essences considered in the intellect, and the objects of science, that is, essences considered in concrete particulars, share a common element, namely, the essence considered in itself. It is the very fact that logic and science share a common element that ensures that the objects of logic map onto the objects of science in certain salient ways. Second, the objects of logic and science

¹⁸ Some Latin scholastics, most notably Henry of Ghent, were willing to embrace the notion of essences' having a quasi-existence and so introduced the idea of *esse essentiae*, as opposed to *esse existentiae*. For an account of Henry of Ghent's position concerning essences see J. WIPPEL, *The Reality of Nonexisting Possibles*, « The Review of Metaphysics », 34, 1981, pp. 729-758.

differ owing to the different accidents that accrue to the essence in itself given its ontological location either in matter or in the intellect. Through a process of abstraction the scientist strips away these accidental features and conceptualizes the essences in themselves independent of the accidents that follow upon their ontological location either in concrete particulars or in the intellect. Thus insofar as one abstracts or sets to one side the mental accidents following upon the quiddities *qua* in the intellect the conclusions derived from logical reasoning, inasmuch as they concern the essences in themselves, exactly map onto the essences in themselves existing in material things. In other words, logical objects considered free of the mental accidents following upon the quiddities *qua* in the intellect capture the way the world is insofar as the objects of the world are considered free of the material accidents following upon the quiddities *qua* in a concrete particulars. Essences in themselves, far from bloating Avicenna's ontology, are the bedrock that underlies his anti-skeptical views concerning the possibility of scientific knowledge as well as his scientific realism. Essences in themselves provide the link between the world as it is and the world as we conceptualize it, guaranteeing that the two in very important ways are identical.

Let us approach this same issue, namely, the relation between the essences in concrete particulars and in the intellect, from a different vantage point. Now let us consider it not in terms of ontology and Avicenna's philosophy of science, but in terms of Avicenna's generative psychology, namely, how we come to have the concepts of various things. This perspective will hopefully further clarify Avicenna's position.

For Avicenna, essences considered in concrete particulars are in a very real sense prior to the essences as they exist in the mind (at least with respect to human minds), a point to be argued in section II below. Like Aristotle before him Avicenna maintains that all human knowledge begins with the perception of concrete particulars, a memory of which is retained in the soul¹⁹. After multiple observations, one can begin to reflect upon common features that the remembered observed particulars share. In this respect one abstracts away from the particular features associated with the observations, such as the time and place as well as size, shape, color and the like associated with the concrete particulars one has observed in the past²⁰. As such one

¹⁹ ARISTOTLE, *Posterior Analytics*, II, 19, 99b35-100a14 and *Metaphysics*, A, 1, 980a27-981b10; AVICENNA, *Kitāb al-Burhān* ed. cit., II.5.

²⁰ For the traditional account of Avicenna's theory of 'abstraction' see F. JABRE, *Le sens de l'abstraction chez Avicenne*, « Mélanges de l'Université St. Joseph de Beyrouth », 50, 1984, pp. 281-310. For a more recent, and I believe more accurate, account see D. N. HASSE, *Avicenna on Abstraction*, in R. WISNOVSKY ed., *Aspects of Avicenna*, Markus Wiener Publishers, Princeton, NJ 2001, pp. 39-72.

simply attends to what seems similar about the observed particulars. To the extent that one has successfully set aside most, if not all, of the particular circumstances surrounding one's past observations of a class of seemingly similar things, then one might be said to have a unified experience of that class of things, but not knowledge in the sense of understanding what is necessary and universal about that class. This process of abstraction and special attention, then, is preparatory for knowledge²¹. It is like having an amorphous image or phantasm, say of human, where one is neither considering such features as being at this time or that time, here or there, male or female, white or black, tall or short, fat or thin²². Once the observer has this amorphous image and so is properly prepared, the Active Intellect (*al-'aql al-fa'āl*), according to Avicennan psychology, 'illuminates' the image, in which case the observer now has knowledge of what it is to be human. In other words, one now conceptualizes the essence of human in his intellect as something no longer particular, but universal. In Avicenna's own words, then, the final stage of cognition occurs when there is « 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 »²³. On my understanding of Avicenna, the 'light emanated upon the soul' is nothing other than the Active Intellect's imparting intellectual

²¹ Avicenna himself describes this process of beginning with perceptibles, and then moving through a process of abstraction and special attention in his *Kitāb al-Burhān* thus: « [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 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 power, 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 'Amr 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] (AVICENNA, *Kitāb al-Burhān* ed. cit., III.5, p. 160.7-17).

²² In the *Physics*, he refers to this amorphous image or phantasm corresponding with one's unified experience as a 'vague and indeterminate individual' (*shakhṣan muntashiran ghayr mu'ayyan*); see AVICENNA, *aṭ-Ṭabī'iyāt* ed. cit., I.1, pp. 10.11-11.9.

²³ *Ibid.*, III.5, p. 161.6-7.

accidents, such as universality, to the essence considered in itself. Prior to this emanation, however, the essence considered in itself must be prepared to receive these intellectual accidents, where the preparation takes place through the observer's own act of abstraction and stripping away, that is, not attending to the accidents that follow upon the essence's existence in matter.

For our purposes what is important to note about the interpretation given is that the Active Intellect does not simply impart the universal to the soul *in toto*, that is, as a composite of an essence in itself and universality²⁴. Quite the contrary, it imparts only the accident of universality to an essence in itself that itself results only after the human has had multiple encounters with concrete particulars and abstracted away the various particularizing accidents that follow upon an essence's existing in matter. The essence in itself, then, guarantees that the relation between the essence existing in matter and the essence existing in the soul is not a mere correspondence or similarity relation, but a much stronger relation, namely, a partial identity relation, inasmuch as the essence in itself, considered independent of the accidents of particularity and universality, is exactly the same in both. Logic is applicable to science, because in a very real sense the objects of logic are the objects of science, not so much owing to the universality of the predicables, but owing to the common essence in itself considered by both logic and science.

II

Thus far I have spoken to the issue of Avicenna's general view about the relation between the objects of logic, that is, universal predicables, and the objects of scientific inquiry, that is, the various kinds of concrete particulars and their causal interactions. We have seen that both the objects of science and logic share a common element, namely, the essence considered in itself, and it is because they do share a common element that logic is applicable to science. There are, however, certain limits and caveats that Avicenna makes to the general application of logic to science. I shall consider two of these. The first is the difference Avicenna notes between the logical notions genus and difference, and between two of the causes appealed to in science, namely,

²⁴ For an interpretation of Avicenna's theory of cognition that is in stark contrast to the one presented here, namely, one arguing that for Avicenna the Active Intellect gives the intelligible form or essence wholly to the human and not merely the accident of universality, see S. NUSEIBEH, *Al-'Aql al-Qudsī: Avicenna's Subjective Theory of Knowledge*, « *Studia Islamica* », 69, 1989, pp. 39-54, and ID., *Epistemology*, in S. H. NASR, O. LEAMAN eds., *History of Islamic Philosophy*, Routledge, London-New York, 1996 (Routledge History of World Philosophies, 1), ch. 49, pp. 836-838.

matter and form. As we shall see for Avicenna the extra-mental causes, namely, matter and form, are prior to the predicables, namely, genus and difference, inasmuch as the latter are in some sense dependent on the former for their existence. The second caveat mentioned by Avicenna, which I shall treat in the next section, is the use, or misuse, of negative terms in scientific definitions. Logic itself is indifferent to the use of either negative or positive predicates ; so, for example, the propositions 'animals are sensate' and 'plants are non-sensate' are both logically well-formed. Given logic's indifference to the use of negative predicates, one might be tempted, as Porphyry was, to define plant as 'an animate, non-sensate substance', where 'animate [substance]' indicates the genus and 'non-sensate' the difference. As we shall see for Avicenna scientifically adequate definitions cannot be constructed in negative terms, except in very limited cases. In the final section of this study we shall see one case where all these elements come together in a scientific investigation, and how Avicenna uses logic as a tool of scientific discovery.

Avicenna discusses the difference between the logical predicables, genus and difference, and the scientific causes, matter and form, at *Kitāb al-Burhān*, I.10, his work most specifically dedicated to what we might call 'philosophy of science'. Although Avicenna argues that the objects of logic and science are *partially* identical, he does not believe that they are not *wholly* identical. There is a difference between the material and formal causes that science investigates and the logical notions of genus and difference that in a sense stand in for the scientific causes in logical reasoning. Here Avicenna motivates the need to distinguish them by raising a puzzle :

« One of the greatest causes of confusion concerns how animal is a cause of the human's being a body, given what we have claimed about that ; for as long as the human is not a body, then neither is it an animal. Or how is [animal] a cause of the human's having sensation, when as long as the human does not have sensation, then neither is it an animal, because corporeality and sensation are both causes of the existence of animal ? As long as something does not exist, then the existence of whatever depends upon it does not exist. Also, when the account (*ma'nā*) of the soul is joined with the account of body, such that it is the composite of the two, not just one of them, that is an animal, then how can the body be predicated of the animal ? In that case, it would be just as predicating the single thing of the two. Similarly, how can being animate be predicated of the animal, in which case it would be just as predicating the single thing of the two ? »²⁵.

²⁵ AVICENNA, *Kitāb al-Burhān* ed. cit., I.10, p. 49.

Avicenna presents us with two related puzzles that are intended to cast doubt on his own belief that animal causes the body to be the specific kind of body it is, as for instance a human body; and moreover that it causes that body to have the specific functions it has. Thus, the position Avicenna wants to maintain, but the puzzles seem to undermine, is that being an animal is prior to the body and the functions of that body, inasmuch as a cause is prior to its effect, and being an animal is a cause of both a body's being the kind that it is and the body's having the functions that it has.

The first puzzle seems to call such a view into doubt by arguing that being an animal is defined as being a body with sensation, that is, 'being an animal' is constructed, as it were, from the more basic or prior elements 'having a body', which is a genus, and 'having sensation', which is a difference. Thus corporeality and sensation in this respect would seem to be prior to being an animal. The second puzzle, which is a variation on the first, also concerns an issue of priority. Assume that 'animal' is the subject for the predicate 'being a body', as in the example, 'All animals (subject) are bodies (predicate)'. In this case, however, since 'animal' is defined as 'a body with sensation', to predicate 'body' of 'animal' is just to say 'a body with sensation is a body', which hardly seems scientifically informative. Moreover, it would seem that such predication requires making 'body' and 'having sensation' prior and explanatory of being animal, and yet again Avicenna's own position is that it is animal that is the cause and so is prior to either body or having sensation.

The confusion is resolved, claims Avicenna, once we distinguish the body *qua* matter from the body *qua* genus, and similarly with sensation *qua* form and sensation *qua* difference. The body as matter is the body only insofar as it possesses length, breadth and depth and nothing else. Any other qualifications are additional to the body as matter. In this respect, one might think of the body *qua* matter as the thinnest possible account of body required to make something be a body; for if something is not three dimensional, it would be difficult, if not impossible, to say, in any meaningful sense, that it is a body.

In contrast, the body considered as genus is the body conceptualized as possessing three dimensions in addition to every other possible description or account that we might associate with the term 'body' when we conceptualize various bodily things, and so it may include a myriad of other accounts or description over and beyond simply being three-dimensional. Here the body as genus is considered as the totality of all «constituents internal to the identity of that substance [that is a body]» (*mujtami'āt dākhila fī huwīya dhālika l-jawhar*), not merely as something possessing length, breadth and depth only. Indeed, Avicenna invites us to include within the meaning of 'body' every possible account compatible with being a body, even if those accounts are in reality mutually exclusive in any single body. Thus body

considered as genus would include the accounts belonging to both, animate and inanimate bodies, sensate and insensate bodies as well as rational and irrational bodies. In other words, 'body' *qua* genus involves everything that we might include in our conceptualizing the meaning of our utterance 'body'. In this respect, one might think of the body *qua* genus as the thickest possible account of body that is still compatible with the notion of body. Thus concludes Avicenna:

« Since the body in the first sense [i.e. as matter] is a part of the substance composed of body and forms, which are posterior to the corporeality that is in the sense of matter, [body] is not something predicated (*maḥmūl*), because that totality is not some abstract substance possessing only length, breadth and depth. This second [i.e., body as genus], however, is something predicated of whatever is a composite of matter and form, whether one form or a thousand, among which are the three dimensions. Thus [the body *qua* genus] is predicated of what is composed of corporeality, which is like matter, and soul, because the totality of that is a substance »²⁶.

Avicenna's discussion of the body as matter anticipates certain details about his conception of the relation between matter and form, which he would subsequently develop in his *Physics*²⁷. Still his general point, I believe, is clear. The material cause of a human is body that possesses only the form of corporeality or three-dimensionality, namely, body taken in the thinnest possible sense. Matter as such is nothing more than a certain potentiality for or receptivity to a certain species form. Taken just as possessing three-dimensionality, body has no determinate existence — nothing exists just as three dimensional without any other specifications — and so whatever determinate existence the body has is due to the species form that causes the body to be the specific body it is. In this respect, being an animal is the active cause that configures body, which is the passive cause, such that there is the determinate existence of the animal body. Three-dimensional body, then, does not function as some (pre-existing) subject to which being an animal is subsequently predicated, a position that Avicenna takes to be absurd. Quite

²⁶ AVICENNA, *Kitāb al-Burhān* ed. cit., I.10, p. 50.

²⁷ See AVICENNA, *aṭ-Ṭabī'iyāt* ed. cit., I.2, pp. 13.4-15.5. For studies of Avicenna's theory of matter see A. HYMAN, *Aristotle's 'First Matter' and Avicenna's and Averroes' 'Corporeal Form'*, in *Essays in Medieval Jewish and Islamic Philosophy*, KTAV Publishing House Inc., New York 1977, pp. 335-356; E. BUSCHMANN, *Untersuchungen zum Problem der Materie bei Avicenna*, Peter Lang G.m.b.H, Frankfurt am Main 1979; and more recently A. D. STONE, *Simplicius and Avicenna on the Essential Corporeity of Material Substance*, in WISNOVSKY ed., *Aspects of Avicenna* cit., pp. 73-130; and MCGINNIS, *The Avicennan Sources for Aquinas on Being* cit.

the contrary, matter and form, or in our example three-dimensional body and animality, jointly constitute, and so cause, a specific kind of substance, namely, an animal. Consequently, the form of animal is, as it were, an 'amplifying factor' that fills out body considered in its thinnest sense and as such causes a determinate kind of body to exist. Without the form of animality (or some other species form) no body would exist, because body simply cannot exist only as indeterminate three dimensions.

When one considers the body as genus, however, one considers body in its thickest sense and as such it contains every possible account that is included in our conceptualizing the meaning of the word 'body', such as being an inanimate body and animate body, an insensate body and sensate body, an irrational body and a rational body. Thus when 'animal' is the logical subject of 'being a body', as in the proposition, 'All animals are bodies', and so 'body' is considered *qua* genus, then the subject 'animal' differentiates the genus 'body', and so specifies a given species of body. In other words, the subject 'animal', as it were, contracts the genus 'body' (with all the various, indeed even frequently mutually exclusive, accounts) to a certain species of body, namely, 'animal body'. In this case 'animal' is not an amplifying factor, but instead might be thought of as a 'limiting factor'.

Avicenna continues that this same analysis holds when considering animal ; for animal as a corporeal, self-nourishing, sensate thing, namely, animal taken in the thinnest possible sense, is analogous to matter. Again, however, nothing simply exists as an animal, but exists only as a definite species of animal. In this case the rational soul, for example in humans, is the active cause configuring and amplifying animal, which now takes the place of the passive cause, such that the determinately existing species human results. Again, just as in the case where body was taken as matter, animal is not some (pre-existing) subject to which being rational is subsequently predicated or superadded ; rather, animal and the rational soul jointly constitute, and so cause, the existence of the human.

When one no longer takes animal simply under this thin account, but considers animal as including every possible account compatible with our conceptualizing the term 'animal', such as rational animal, neighing animal, braying animal (as well as any other account of any given animal), 'animal' does function as a predicate, as in the proposition, 'All rational [material substances] are animals'. In this case, 'being rational' differentiates the genus 'animal' and uniquely picks out or contracts the genus 'animal' to the species 'human.' It is this process of picking out more and more specific things that ultimately provides the scientist with a unique scientific definition of a given species in terms of genus and difference. In this respect logic provides a valuable function in science, inasmuch as the propositions formed in logic

provide the definitions and premises suitable for scientific demonstrations, that is, the logically valid inferences that appeal to the logical equivalents of causes in their premises.

The point that Avicenna stresses throughout this chapter is the priority of causes over predicables. As things exist in the world, the more general kinds of things — such as substance, animal and the like — presuppose the existence of, and indeed are caused to exist by, the more particular things. Scientific analysis, then, involves uncovering the more and more basic causes, each one of which is prior to and explanatory of what stands above it. Thus body has a determinate existence because animal exists, and animal has a determinate existence because human (or some other species) exists. In this respect human is ontologically prior to either animal or body.

Only after the scientific analysis of the kinds of things into their causes is there a logical ordering of those kinds in terms of genera and differences and then species. Thus in the logical ordering 'body' is considered to be prior to 'animal' inasmuch as 'animal' is merely a specification of the more general and basic logical notion of 'body'. In its turn 'animal' is logically prior to 'rational' inasmuch as 'rational animal' is only a limited class of the more general and basic logical genus 'animal'.

It is because the logical ordering from more general to more specific mirrors the causal ordering from the more particular (or determinate) to less particular (or determinate) that logical definitions in terms of genus and difference map onto the true natures of thing, where the logical terms can function as proxies for the material and formal causes in logical inferences. The effect of this mirroring of the ontological ordering by the logical ordering is that if any determinate kind exists in the world as a result of certain material and formal causes (or is in some way a composite of potentiality and actuality), then that kind will have a definition in term of the logical counterparts of matter and form, namely, genus and difference. Avicenna observes, « These differences, though trivial in themselves, are useful in the sciences, and should not be undervalued »²⁸, and in the last section of this study we shall see just how they can be useful for science.

III

Before that, however, we must consider yet another caveat or limitation that Avicenna places on the application of logic to science. In Avicenna's chapter dedicated to the difference (Grk. *diaphora*, Arb. *faṣl*) in his *Madkhal*,

²⁸ AVICENNA, *Kitāb al-Burhān* ed. cit., I.10, p. 52.22.

he censures Porphyry's and other logicians' accounts of the difference on a number of points. For our purposes the most important one is Porphyry's suggestion that negative differences, such as 'immortal' and 'irrational', not only divide a genus, but constitute a species. Avicenna vehemently complains that insofar as these differences are negative they do not map onto any positive feature in reality, and thus could not constitute a species²⁹.

In the *Eisagog^o*^a Porphyry distinguishes between 'dividing' (Grk. *diaretik^a*, Arb. *muqassim*) and 'constitutive' (Grk. *sustatik^a*, Arb. *muqawwim*) differences. Porphyry remarks that concerning dividing differences :

« These dividing differences complete the genera and become constitutive of the species ; for animal is divided both by the difference of rational and irrational, and again by the difference of mortal and immortal. The differences mortal and rational become constitutive of man, those of rational and immortal of god, those of irrational and mortal of irrational animals. Since the differences animate and inanimate and that of sensate and insensate divide the highest substance, animate and sensate, combined with substance, complete animal, while animate and insensate complete plant. Since, therefore, the same differences understood in one way become constitutive and in another way become divisive, they are all called specific »³⁰.

Although Avicenna accepts Porphyry's point that whatever is not a dividing difference is not a constitutive difference, he denies Porphyry's further claim that every dividing difference is a constitutive difference. In particular, Avicenna takes issue with the examples that Porphyry has given such as 'immortal', 'irrational' and 'insensate' ; for inasmuch as these indicate negations they simply cannot function, according to Avicenna, as some positive constituent of a species.

Avicenna begins by admitting that there are at least two cases where negative differences might constitute a species. The first is where the negative difference establishes a species exactly mirroring (*naw^ʿ muḥaṣṣil bi-izā*) the species

²⁹ Other points with which Avicenna takes issue with Porphyry and others are (1) although they distinguish between a common and technical use of 'difference', their subsequent discussions move indiscriminately between the common and technical use ; and (2) Porphyry and others have failed to provide a scientifically adequate definition of difference, that is, a definition that is itself in term of genus and difference, since the previous accounts fail to make clear what the genus of the definition of 'difference' is.

³⁰ PORPHYRII *Isagoge et in Aristotelis Categorias commentarium*, ed. A. BUSSE, Berlin 1897 (Commentaria in Aristotelem graeca, IV, 1), pp. 10, 9-19 ; translation after E. W. WARREN, *Porphyry The Phoenician, Isagoge, translation, introduction and notes*, The Pontifical Institute of Mediaeval Studies, Toronto 1975 (Mediaeval Sources in Translation, 16), pp. 44-45.

constituted by the positive difference. So, for example, the genus of rational numbers is divided into numbers that are divisible into two equal parts, namely, the 'even', and numbers that are *not* divisible into two equal parts, namely, the 'odd'. Here, however, the negative difference, 'not divisible', does not produce a pastiche of species loosely collected under the umbrella 'not divisible into two equal parts'; rather, 'not divisible into two equal parts' differentiates one single species parallel to the species even, namely, the species odd.

The second case where a negative difference may be used to establish a species is when there is in fact some positive factor or difference that divides and constitutes the species, but that difference has no definite name, and so as a matter of exigency one is forced to use a negative expression. Avicenna gives the following fictional example. Imagine that the genus 'animal' had only two species: 'human' and 'horse'. From our vantage point, he continues, the horse's (positive) difference is 'neighing', but imagine that in our fictional world of only two animals there is no term or word 'neighing'. In this case, says Avicenna, it would be acceptable to divide 'animal' into 'rational' and 'irrational'; however, here, 'irrational' is merely an ersatz used in lieu of the real (positive) difference, being something that neighs.

As a general rule, however, negative terms are not differences; rather, Avicenna argues,

« negations are entailments belonging to things relative to a consideration of certain (positive) accounts (*ma'ānin*) that do not belong to [the things]; for 'irrational' is something intellectually understood by considering rational, in which case the species, its (positive) account and its difference that belongs to it, are in the thing itself, and thereafter it is entailed of it that it is not described by anything else »³¹.

Here Avicenna is attempting to shave nothing less than *Plato's beard*, the paradox that what is not must at least in some sense be, otherwise what is it that is not?

On Avicenna's analysis, when a certain thing, *x*, is said to be, for example, 'irrational', irrational is not some positive constituent of *x* itself; rather, according to Avicenna, *x* has certain positive accounts or factors that constitute it, and rational fails to be among those positive features. Predicating a negation of something, then, is relative to and follows upon a consideration of those features or factors that actually belong to a thing, and only subsequently is a negation like 'irrational' predicated of the thing and then only if it is found that some positive account such as 'rational' fails to belong

³¹ AVICENNA, *Madkhal* ed. cit., I.13, p. 79.3-5.

to it³². As such negations are parasitic on what is. A real difference or difference in the strict sense (*khāṣṣ al-khāṣṣ*), that is, the difference that goes into making a definition, is something positive that mirrors some real feature of the world.

Avicenna's point here is not merely an incidental aside; rather, he is making a substantive point about the very nature of a scientifically adequate definition. As we have seen, science for Avicenna attempts to provide an explanation of the more general kinds of things in term of progressively more particular or determinate causes. In contrast, logic, drawing on the results obtained by scientific analyses, begins with the higher levels of generality and then moves down to the more specific. Logical definitions, thus, must be of such a nature that the predicables used in the definition, that is, the genus and difference, map onto what is in fact in the world. Consequently, given that negations are not things in the world, but only concomitants relative to positive things in the world, definitions in terms of negation simply will not, indeed cannot, map onto what is (again setting aside the exceptions that Avicenna had mentioned). Thus if the scientist allowed definitions construed in term of negations, there would be a serious disconnect between the objects of science and logic such that logic's general applicability to science would be thrown into doubt. In general, then, scientifically adequate definitions must be in term of positive accounts that mirror the actual causes in the world.

IV

I conclude by considering how Avicenna applies these abstract points concerning the relation between logic and science to a practical problem in the science of physics. The problem concerns the void and more exactly whether the void exists. Avicenna notes that the standard way that Aristotle and those following him had approached this problem was by means of 'physical argumentation' (*al-kalām aṭ-ṭabī'ī*). The proponents of the void had argued that its existence was necessary in order to explain motion; Aristotle subsequently turned the table on the proponents of void and argued that the existence of the void physically would preclude the possibility of motion. Although Avicenna himself would once again rehearse Aristotle's physical

³² Avicenna's treatment of negative terms is similar in certain salient ways to Quine's analysis of them in W. V. O. QUINE, *On What There Is*, in Id., *From a Logical Point of View*, Harvard University Press, Cambridge, MA 1953, pp. 1-19, esp. 7-9. Quine's analysis is framed in terms of 'descriptions', whereas Avicenna's is framed in terms of 'positive accounts'; yet both would agree that the proper analysis of 'x is not' is « each thing failed either to meet a certain description or to have a certain positive account ».

arguments, and indeed add some additional physical arguments of his own, he thinks that there is a simpler and more eloquent way to demonstrate the non-existence of the void based solely on logical considerations.

Although what we might call Avicenna's 'logical argument' or 'conceptual argument' against the void is detailed at its various moments, its general structure is quite simple³³. Avicenna takes as his major premise one of the conclusions that we have already encountered, namely, if something in the physical world actually exists, then it is possible to provide a definition of that thing in terms of genus and difference; conversely — again limiting ourselves to the physical world — if it is impossible to provide a definition of some concept or expression in terms of a genus and difference, then the term does not refer, and in fact the concept is simply a vain intelligible (Arb. *ma'qūlan mafrūghan minhu*)³⁴. Avicenna will then exhaustively consider the various ways one might provide a definition of the void and argue that they are all in some way wanting. Given the impossibility of providing a scientifically adequate definition of void, Avicenna concludes that the expression 'void' does not refer to anything actually existing in the physical world.

Avicenna's argument for his major premise here is just a repetition of the argument from *Kitāb al-Burhān*, which we have already seen, and so we can simply consider his reasons for denying that a scientifically adequate definition of a void is possible. Again, however, even this limited part of Avicenna's discussion is quite extensive and detailed, and thus we shall have to content ourselves with a simple summary rather than a detailed analysis of his argument.

Avicenna begins by observing that the sense of void cannot be that it is absolutely nothing; for if that were the case, there would be no dispute, since if void is absolutely nothing, then it does not exist. The void, should it exist, must be something. In fact, the advocates of the void assign to it certain positive properties, such as being extended and measurable, and thus they themselves take void to be something. Now the void, should it exist, must have these properties, namely, being extended and measurable, either (1) essentially or (2) accidentally. Moreover, since both extension and measurability belong to quantity, if the void has these properties essentially, then it itself is quantity essentially, whereas if it possesses them accidentally, then what possesses them must be either (2.a) an accident or (2.b) a substance.

³³ The argument comes from AVICENNA, *aṭ-Ṭabī'iyāt* ed. cit., II.8, pp. 123.7-126.6.

³⁴ For studies of Avicenna's position concerning non-existent forms or 'fictional beings' see J. [Y.] R. MICHOT, *Avicenna's 'Letter on the Disappearance of the Vain Intelligible Forms after Death'*, « Bulletin de Philosophie Médiévale », 26-27, 1984-85, pp. 94-103; Id., 'L'Épître sur la disparition des formes intelligibles vaines après la mort' d'Avicenne, « Bulletin de Philosophie Médiévale », 29, 1987, pp. 152-170; and D. L. BLACK, *Avicenna on the Ontological and Epistemic Status of Fictional Beings*, « Documenti e studi sulla tradizione filosofica medievale », 8, 1997, pp. 425-453.

If (1) the properties of extension and measurability belong to the void essentially, void is essentially a quantity, and indeed a quantity with three dimensions. In earlier chapters of his *Physics*, Avicenna had extensively argued that the very nature of tri-dimensionality is to imprint and configure matter³⁵. Thus if the very essence or nature of void were tri-dimensionality, then it would necessarily imprint and configure matter. We are left to assume that the proponents of the void would deny that the void actively imprints the bodies that pass through it ; for the void is thought to be something passive that bodies simply moves through, not something that in some way constitutes or acts on a body.

If (2.a) the void is an accident of an accident, it exists in the way that, for example, red exists as something accidentally extended inasmuch as it is in an extended surface, where the extension of the surface, a quantity, is itself an accident of a substance. Void so considered could belong to the accidental quantity belonging to a substance either as (2.a.i) some internal constituent of the substance's quantity or (2.a.ii) or as a non-constitutive accident belonging to the quantity of the substance. If (2.a.i) void is an internal constituent of the substance's quantity, then it would stand to quantity and substance analogously to the way rationality stood to animal and body in the *Kitāb al-Burhān* passage. Consequently, void would be an essence (*dhāt*) constitutive of the quantity belonging to a substance. In that case, however, since a quantified substance just is a body, the void would be a causal factor of the substance's being a body, which, of course, the proponents of the void would deny³⁶. If (2.a.ii) the void is a non-constitutive accident of the substance's quantity, then void can no longer play the role for which it was intended, namely, as that which bodies enter and move through ; for no body enters and moves through an accident, and yet the proponent of the void thinks that bodies do enter and move through the void³⁷.

Avicenna now turns to (2.b), the suggestion that void is an accident of a substance rather than an accident of an accident ; however, the language shifts from considering void as an 'accident' of a substance to considering it as a 'difference' of a substance. The shift is warranted inasmuch as Avicenna is trying to find out what the definition of 'void' might be, and so is not considering the scientific account of substance, but the logical account of

³⁵ See AVICENNA, *aṭ-Ṭabī'iyāt* ed. cit., I.2, pp. 13.4-15.5 and II.7, pp. 120.15-122.8 ; for a detailed analysis of Avicenna's argument for this claim see J. MCGINNIS, *A Penetrating Question in the History of Ideas : Space, Dimensionality and Interpenetration in the Thought of Avicenna*, « Arabic Sciences and Philosophy », 16, 2006, pp. 47-69.

³⁶ AVICENNA, *aṭ-Ṭabī'iyāt* ed. cit., II.8, p. 124.2-4.

³⁷ *Ibid.*, p. 124.4-6.

substance *qua* genus. From what we have seen in *Kitāb al-Burhān*, substance as a genus for Avicenna would be the 'thickest' conception of substance compatible with being a substance, and as such it would include every possible account of the ways substance might be. In this case, since the one constructing the definition applies a given difference to a genus so as to limit or contract that genus to a more specific class of things, one might say that the difference 'befalls' or 'happens' to the substance considered as a genus inasmuch as the generic notion of substance does not necessitate the specific existence of this particular difference to the exclusion of some other perhaps mutually exclusive difference; however, when it 'happens' or 'befalls' that the substance is so specified by such a difference, the genus 'substance' is progressively made more and more specific. Here, however, 'befalls' and 'happens' are both ways of translating 'arāḍa, ya 'riḍu, 'arḍ and its derivatives, the term that underlies the Arabic philosophical use of 'accident'. In short, when one is considering the logical ordering, the difference in a sense is an accident inasmuch as the genus itself need not be essentially specified by this particular difference and no other difference.

Returning to the argument, Avicenna invites us to think of void as falling under the genus 'substance', and it falls under it either as (2.b.i) something that exists in a substrate or (2.b.ii) something that does not exist in a substrate³⁸. In this case, 'existing in a substrate' and 'not existing in a substrate' might be thought of as dividing differences of the genus 'substance'. On the one hand, if (2.b.i) the void exists only as something in a substance as its substrate, then should the substance not exist, neither would the void exist, but of course the proponents of void think that the void exists whether it is occupied by a substance or not. On the other hand, *not* existing in a substrate (2.b.ii) is inadequate as a difference of substance that constitutes a scientific definition; for as we have seen a negation cannot function as a difference in scientific definitions³⁹. Thus some positive factor must function as a difference in the strict sense required by a definition if there is to be a scientifically adequate definition of the void.

³⁸ *Ibid.*, p. 124.7-16. The difference Avicenna seems to be marking is that between material substances and immaterial substances, or the so-called 'separate Intellects'.

³⁹ Of course, there are the exceptions that we mentioned; however, in the case of both exceptions, the use of a negative difference produced two and only two parallel species. If *not* existing in a substrate, thus, were such a negative difference, then there should be only one species of substance not existing in a subject, namely, void; however, all the Intellects or 'angels' are also substances not existing in a subject. (Although the difference for separate Intellects is often identified with the negative term, 'incorporeal' or 'immaterial', there is also a common positive difference applied to them by medieval Arabic thinkers, namely, 'spiritual' (*rūḥānī*). Therefore, 'not existing in a substrate' fails to meet the necessary requirement for being a difference.

Although Avicenna's discussion at this point becomes sketchy, he at least suggests some possible positive features to which the advocates of void may try to appeal in order to provide a proper definition of void⁴⁰. As one might expect he finds all of these suggestions wanting. So, for example, one might claim that the void's difference is being susceptible to division in three dimensions, but of course this is true of all magnitudes, and so is not a strict difference. One may try to refine this account and say void is an *indeterminate* (*bilā taḥṣīl*) substance, but such a suggestion once again appeals to a negative difference. There is at least the fleeting suggestion here that one might consider the tri-dimensionality of the void as in some way absolute dimensions, perhaps akin to the magnitudes that mathematicians treat as opposed to the tri-dimensionality that informs matter. If we allow ourselves to go beyond Avicenna's text, we can observe that for Avicenna the dimensions that mathematics treats are different from the dimensions existing in matter inasmuch as mathematical dimensionality exists in the intellect after a process of abstraction that initially began by considering materially extended objects⁴¹. Thus there is a positive difference between material dimensions and mathematical dimensions, namely, the former exists in concrete particulars, while the latter exists in the intellect. The proponents of void, then, must state what the difference is between the purported void's dimensions and either material or mathematical dimensions. Of course to claim that the void's dimensions *neither* subsist in the concrete particular *nor* in the intellect would again only be an appeal to a negative difference, and so such a claim would not provide a real difference in the strict sense.

Avicenna sums up his discussion: « This division between a [three-dimensional] interval in matter and an interval not in matter is not a division by means of a species making difference ; rather, it is a division by means of some concomitant accidents external to the constitution of the interval as a species »⁴². Having argued extensively in *Kitāb al-Burhān* that if something

⁴⁰ AVICENNA, *aḡ-Ṭabī'īyāt* ed. cit., II.8, pp. 125.9-126.6.

⁴¹ Accounts of Avicenna's philosophy of mathematics are few. For now see R. RASHED, *Mathematics and Philosophy in Ibn Sīnā*, in M. CUNBUR, O. DOĞAN eds., *Uluslararası İbni Sīnā Sempozyumu*, Basbakanlık, Ankara 1983, pp. 131-138 ; Id., *Mathématiques et Philosophie chez Avicenne*, in J. JOLIVET, R. RASHED eds., *Études sur Avicenne*, Les Belles Lettres, Paris 1984, pp. 29-39 ; and A. A. AL-DAFFA, J. STROYLES, *Ibn Sīnā as a Mathematician*, in A. SAYILI ed., *Ibni Sīnā Doğumunun Bininci Yılı Armağanı*, Türk Tarih Kurumu Basımevi, Ankara 1984, pp. 67-140, especially section VI, « Foundations ».

⁴² AVICENNA, *aḡ-Ṭabī'īyāt* ed. cit., II.8, p. 126.4-6. It might be worth noting that Avicenna's language here is the same language he used to explain negative terms in his *Madkhal*, and again recall that, except for the limited exceptions mentioned concerning negation, negations simply do not exist in the world, and so cannot function as differences.

exists in the physical world, then one must be able to provide a scientific definition of it in terms of genus and difference, and yet nothing can adequately function as the void's difference in such a definition, Avicenna concludes that the notion of void is a vain intelligible.

What is of particular interest in Avicenna's argument here is that it shows how Avicenna conceived of logic as a tool for science. Certainly, logic can be used to formalize a body of scientific knowledge in such a way as to allow scientific demonstrations; however, it can also play important roles in the process of scientific discovery itself, as we have seen in the case of the void. Avicenna was able to conclude on the basis of logical or conceptual considerations alone that the void could not exist; for if it were to exist, then it would be possible to provide a logical definition of 'void' in terms of genus and difference. Although there is a sense in which Avicenna's argument here against the reality of the void appears to make logical considerations prior to physical considerations, it can do so because concrete particulars and their causal relations determine in a very strong sense the nature of logical objects themselves, such as the predicables, and their logical relations. It is the essences of things considered in themselves, initially and primarily existing in the concrete particulars, and then secondarily and derivatively existing in the intellect after a process of abstraction and illumination, that ensures the applicability of logic to science. In this respect logical considerations can indicate what could or could not exist in the world as well as suggest how the world 'ought' to be; however, it does not do so as some formalized ideal that science must live up to, but as something that reflects and maps onto the world order itself.