LOGIC, PHILOSOPHY OF SCIENCE AND THE QUALITY OF LIFE

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Contents

Summary

The aim of this chapter is to introduce some of the most basic concepts and issues in the broad field that has traditionally been known as 'logic and scientific methods', and to connect that field to our contemporary search for global understanding of the nature and

necessary conditions for the development of a sustainable life of the highest quality for the earth's current and future inhabitants.

1. Introduction

The global movement towards sustainable development as evidenced by major Earth Summits of 1992 (Rio) and 2002 (Johannesburg) is based on the assumption that sustainable human development across the whole world is a goal worthy of pursuit by the human community. Unfortunately, it is not a particularly salient or compelling goal for many people, and many of those who do view it as salient and compelling have different ideas about its nature and about the best way to achieve it. Since one's chances of hitting a target tend to improve as one's view of the target is clarified, it is reasonable to expect that the clarification of the goal of sustainable human development will improve our chances of reaching that goal. This chapter is a modest contribution to the quest for clarification.

At least since the emergence of philosophy in the fifth century BCE in ancient Greece, some people have appealed to *reason* as the instrument for solving human problems. Growing up in a world in which the differences between supernatural and natural phenomena were far from clear, and in which the ultimate determinants of life and death were probably more readily perceived as the result of poorly understood and unconstrained passions, brute force and dumb luck, ancient philosophers were rare in number and their outlook on life was even more rare. Perhaps the characteristic that most distinguished philosophers from all other people was their assumption that people have the capacity to *reason* or *think critically* about issues, and that it is both possible and worthwhile to train oneself and others in the efficient and effective exercise of this capacity. What is perhaps even more remarkable than the fact that such people had such insight was the fact that other people apparently appreciated it. Thus, the initiative of a few and the appreciation of many led to the social construction of principles and systems of logic, and methods of critical thinking about the world and its inhabitants. In fact, since the earliest divisions of philosophy from the fifth century BCE included logic, physics and ethics, the structure of this chapter bears a family resemblance to its illustrious ancestors.

In this chapter some of the foundational elements of logic, philosophy and science will be explained. Some light will be shed on the philosophers' understanding of good versus bad reasons for believing some things rather than others, or of reasonable versus unreasonable arguments. Once the general foundation of critical thinking is laid, some foundational concepts of all the sciences will be examined with a view to revealing their variety, strengths and limitations. It is not an exaggeration to say that the total corpus of accepted scientific knowledge rests on the foundations to be examined here. As well, our understanding and appreciation of a sort of life or quality of life that is worthy of pursuing, obtaining and sustaining for present and future inhabitants of planet earth rests on the very same foundations.

2. Logical Foundations

Some claims, assertions, sentences or propositions are *worthy of belief* and some are not. Among those that are worthy of belief, some merit complete certainty relative to some other claims and assumptions, while others merit acceptance short of complete certainty. In both cases, one may be said to have knowledge insofar as one's claims are worthy of belief. The difference between knowing that a claim is true and merely believing that it is true is that knowledge requires a good reason for what one believes. Structurally, a good reason is a good argument, and logic is the study of arguments and things essential to their appraisal as good or bad.

An argument may be defined as a sequence of sentences divided in such a way that some of the sentences are supposed to be the reason, justification, guarantee, warrant or support for some other sentence in the sequence. The sentences that provide the reason or warrant are called 'premises'. The sentence that is supposed to be warranted by the premise(s) is called the 'conclusion'.

An argument whose conclusion is supposed, alleged or claimed to be certain relative to its premises is called 'deductive'. Even if the argument has an error in it and does not do what it is supposed to do, it is called 'deductive.' Calling it 'deductive' does not make it good or bad. It just tells everyone what is to be expected of it. More precisely, it specifies the appropriate rules according to which it should be evaluated.

An argument whose conclusion is supposed, alleged, or claimed to be more or less acceptable relative to its premises is called 'inductive'. Even if the argument has an error in it and does not do what it is supposed to do, it is called 'inductive'. Calling it 'inductive' does not make it good or bad. It just specifies the appropriate rules according to which it should be evaluated.

Notice that the definition of an 'inductive argument' contains the word 'acceptable' rather than the 'probable'. The former is merely more general. Usually the conclusion of an inductive argument is described as more or less probable relative to its premises. But sometimes it is described as more or less likely, well supported, well confirmed, reasonable, useful, sensible and so on. That is, there are many ways to characterize the relation that obtains between the premises and the conclusion of an inductive argument. The somewhat general term 'acceptable' is intended cover this variety.

Good arguments must be truth-preserving in the sense that they never lead from true premises to false conclusions. They must satisfy our intuitive notion of a *proof.* The technical name for such arguments is 'sound.' A sound argument must satisfy three conditions. It must be patterned after a valid form, have only true premises and contain no methodological flaws. Each of these three conditions is necessary for a sound argument and collectively the three conditions are sufficient. Thus, an unsound argument is one that fails to satisfy at least one but possibly every one of the conditions for soundness. The first necessary condition for a sound argument is a matter of logical form while the other two necessary conditions are typically (not always) matters of content. Each condition will be examined in turn.

The notion of a valid logical form is perhaps the most important concept in the study of logic. Every argument has a logical form (structure, pattern or skeleton) and some material content. For example, consider the following deductive arguments:

All cats are animals.
All tigers are cats.
So, all tigers are animals.

All humans are mortal.
All Greeks are human
So, all Greeks are mortal.

Each of these arguments is about different things. The first is about animals, cats, and tigers; the second, about mortals, humans, and Greeks. Arguments that are about different things are said to have different contents. So, these arguments have different contents. But they have the very same logical form, pattern, or structure. The form of each of these arguments is this:

All ____ are - - -
All . . . are ____
So, all . . . are - - -

The only words occurring in this skeleton are logical guides called 'logical operators'. The word 'so' tells us that what follows is a conclusion. The words 'all' and 'are' tell us that everything following the former is in the same class as everything following the latter. Just as the whole structure is called an 'argument form', each line is called a 'sentence form', e.g., 'All___are - - -' is the form of the sentence 'All humans are mortal'.

An argument form or skeleton is called 'valid' if, and only if, it *must* yield a true conclusion whenever its place markers (e.g., the solid, broken and dotted lines) are replaced in such a way that each of its premises becomes a true sentence. The ordinary argument obtained from a valid argument form by consistently or uniformly replacing its place markers appropriately is called a 'valid argument'. Hence, the two arguments above (about tigers and Greeks) are valid because they are patterned after a valid argument form, and the argument form in those arguments may be recognized as valid because with the appropriate replacements of its place markers it must produce a true conclusion from true premises.

An argument form is called 'invalid' if, and only if, it is *possible* to uniformly or consistently replace its place markers in such a way that each of its premises is true but its conclusion is false. Such an argument is clearly not truth-preserving in the required sense. The ordinary argument obtained from an invalid argument form by uniformly replacing its place markers appropriately is called an 'invalid argument'. Any argument based on an invalid argument form is an unsound argument. It has a formal defect that is sufficient to render it unsound. On the other hand, any argument based on a valid argument form may be a sound argument insofar as it has satisfied the formal necessary condition of soundness.

Having passed the formal test of validity, sound arguments must pass the material tests of having only true premises and no methodological flaws. The phrase 'methodological flaws' is used to designate a variety of defects in arguments that usually result from informal or material features of arguments, with one notable exception. The notable exception concerns circular arguments. Structurally speaking, as the name suggests, circular arguments have the defect of containing one or more premises that are substantially equivalent to the conclusions that are supposed to be established by those arguments. Accordingly, such arguments are formally valid but methodologically flawed because anyone in doubt about the conclusion of such arguments would have the same doubts about the premises. Apart from the case of circular arguments, methodologically flawed arguments include such errors as proving propositions that are entirely irrelevant to a question at issue, presenting premises that are biased for or against a question, presenting an oversimplified set of premises, using defective definitions of key terms, and using threats or emotional appeals that might lead one to assent to unwarranted conclusions.

While much more will be said in the following sections about the pursuit truth in diverse forms, using diverse procedures, based on diverse assumptions and paradigms, a brief review of theories of truth will provide a useful resting place for this overview of topics in the study of logic that have a particularly important role to play in the philosophy of science.

Very early in school students learn that there are four kinds of sentences, namely, questions or interrogatives (e.g., How are you?), commands or prescriptives (e.g., Close the door.), exclamations (e.g., Ouch!) and declaratives or assertions (e.g., Vancouver is in British Columbia). They also learn that by definition, only declarative sentences can be true or false (i.e., can have a truth-value), and only if they are cognitively or descriptively meaningful. Philosophers have refined the preceding sentence by distinguishing ordinary sentences, which have some physical form such as marks on paper or sounds; judgments, which have some mental form such as ideas in people's heads; and propositions, which are supposed to be the meanings of declarative sentences and have their own special form that is regarded as metaphysical by those who draw these distinctions. (See Section 4 for an explanation of 'metaphysical'.) Using these distinctions, it is more accurate to say that by definition only propositions can be true or false. Thus, for example, one would say that the two distinct sentences 'John is taller than Bob' and 'Bob is shorter than John' have the same meaning or are used to assert or affirm the same proposition. What's more, it is the meaning or proposition that has a truth-value, rather than any particular sentence. Following this tradition, then, our basic question is: What does it mean to say that a proposition is true? Setting aside propositions that are true by definition (about which more is said in Section 4), four theories have been proposed to answer this question.

According to the 'correspondence theory of truth', where 'p' is used to designate any proposition, 'p is true' means 'p corresponds to some aspect of the world'. Thus, for example, if p is replaced by the simple sentence 'Toronto is a windy city', then the proposition that Toronto is a windy city is true just in case there is such a city and it does have the characteristic of being windy. This theory is consistent with ordinary usage insofar as anyone hearing that Toronto is a windy city would suppose the

proposition to be true if it somehow matched the relevant features of that city. The main problem with the theory is that it is not clear exactly what features of propositions must match what features of the world, or exactly what form the matching should take.

According to the 'coherence theory of truth', 'p is true' means 'p is consistent with all other propositions accepted as true'. For example, if it is true that Toronto is a windy city, then it would be reasonable to believe that most people living there would accept the proposition, that residents would take special precautions carrying opened umbrellas, that local news media would carry stories about the effects of winds in the city and so on. This theory is also consistent with ordinary usage insofar as all propositions imply many others that collectively form relatively consistent systems of beliefs or bodies of knowledge that tend to reinforce each other. The main problem with the theory is that it does not have any clear connection to the real world. As a result, two people might have self-consistent systems of beliefs about the world which systems happen to be mutually contradictory, but there would be no means of determining which system was actually true of the world in the sense of the correspondence theory.

According to the 'pragmatic theory of truth', 'p is true' means 'action in accordance with p leads to satisfactory results', where 'satisfactory results' is understood as correspondence with the world *and* consistency with all other propositions accepted as true. That is, the inventors of the pragmatic theory of truth constructed the theory by combining the two basic features of the other two theories. As a result, this theory solves the problem of being able to determine which of two self-consistent but mutually contradictory belief systems is true of the world, but it has nothing special to offer to solve the problem of exactly defining 'correspondence'.

Finally, according to the 'semantic theory of truth', all other theories are defective insofar as they assume that the predicate 'is true' has any descriptive force at all. On the contrary, the semantic theorist says that 'p is true' descriptively means nothing more than 'p' itself. For proponents of the semantic theory, the predicate 'is true' only has expressive or prescriptive force. Thus, for example, 'p is true' has the force of 'Of course p' or perhaps 'Behave as if p', i.e., "'Toronto is a windy city' is true" has the force of 'Of course Toronto is a windy city!' or perhaps 'Behave as if Toronto is a windy city.'. According to these theorists, then, all other theorists failed in their attempts to find the descriptive force of the predicate 'is true' because they failed to realize that sentences patterned after the declarative form 'p is true' are functionally exclamations or prescriptions. This is indeed a radical departure from traditional approaches to the theory of truth. While it has the advantage of capturing some of the nondescriptive force of truth claims, it has the disadvantage of offering a theory that is relatively far from ordinary usage. Instead of rejecting all other theories, it seems more reasonable to accept the fact that truth claims perform diverse functions that are articulated more or less accurately by the different theories.

3. Philosophy of Science

While it has been the logicians' task to explain the differences between good or sound arguments leading to propositions worthy of belief and bad or unsound arguments leading to unwarranted propositions, the task of explaining appropriate methods for

discovering true premises (outside of formal logic and mathematics) has been assigned to other specialists. As late as the middle of the twentieth century, one could still find some introductory logic texts with sections called 'scientific methods', although the authors of those texts knew that disciplines as different as chemistry, sociology, physics and psychology employed many different kinds of methods. The task of searching for common features among the diverse methods used in diverse disciplines fell first to philosophers and historians of science. Their explorations took many forms, including careful inspection of the actual practices of scientists working in different fields as well as careful and critical reflection on alleged good practices. Their aim was not merely to discover features of research regarded as good practice by practitioners, but to discover principles of good practice that would reveal or, if necessary, create some coherence or unity in all scientific investigation.

In the following sections, we will review many of the most important *conceptual features* of scientific practice as those features have been explained by philosophers of science Since the 1920s. It will be shown that science and scientific knowledge is socially constructed on the basis of diverse assumptions, possibilities and priorities. Because it is socially constructed, scientists, philosophers of science and to some extent all members of the human community have a responsibility to ensure that science and scientific knowledge serve the long term interests of that community. More will be said about the identification and measurement of those long term interests in the final section of this chapter. Let us turn now, to a review of some common conceptual features of science and scientific knowledge.

4. Scientific Significance

It was a basic tenet of positivist or empiricist philosophers of science in the 1930s that all cognitively meaningful propositions were either logically true or false, or else in principle experimentally testable. Logically true propositions are often referred to as 'analytic' and are characterized as having self-contradictory denials, or as being true in all possible worlds merely in virtue of the meanings of the terms employed in them.

Nonanalytic propositions are often referred to as 'synthetic' or 'empirical', and a lot of philosophical ink has been shed trying to find a precise criterion of meaningfulness for them. One plausible suggestion was the 'requirement of complete verifiability': A sentence is empirically meaningful if and only if it is not analytic and is implied by a finite logically consistent set of observation sentences. 'Observation sentences' are sentences in which observable characteristics are attributed to objects: e.g., 'This chair is green' or 'John is taller than Frank'.

The trouble with the verifiability criterion is that it makes some scientific laws empirically meaningless. Some laws of nature apply to more objects than anyone could ever observe. For example, there will never be a set of observation sentences that will logically imply the unrestricted generalization 'All men are mortal', since the sentence applies in a totally unrestricted way to all men, including those existing in the future who cannot be observed now. This means that some scientific laws (unrestricted generalizations that are commonly believed to be not only empirically meaningful but true) cannot be regarded as empirically meaningful. Since these laws are quite secure,

the criterion has to be abandoned.

Another candidate to be the criterion of empirical meaningfulness is the 'requirement of complete falsifiability': A sentence is empirically meaningful if and only if its denial is not analytic and is implied by a finite logically consistent set of observation sentences. Unfortunately, this criterion suffers the same fate as the other. Although it allows some unrestricted generalizations to be empirically meaningful, it makes their denials meaningless. This is certainly anomalous because if a given claim is meaningful and therefore true or false, then anyone who denies it must be making a claim that is equally meaningful only false or true, depending on the status of the former. Still, that is just the sort of sour pickle this criterion breeds. So it too has been abandoned.

Weaker criteria of confirmability and testability were suggested, but they also turned out to be objectionable. The criteria always excluded or included too much. Apparently meaningful sentences were ruled out and apparently meaningless sentences were ruled in. Thus, it seemed to some philosophers by the late 1940s that the only way to solve this problem was to design an artificial language whose vocabulary and grammar would prohibit all the unwanted and permit all the wanted sentences. Once again in the history of human affairs, what began as a philosophic sanitation problem was transformed into a philosophic capital works project. Instead of a swift clean-up job, a long-drawn-out development project was proposed.

The analytic-synthetic distinction, explained above, allows us to classify all propositions as follows:

	A priori	*A posteriori*
Analytic	Propositions in formal sciences, such as logic, mathematics	none
Synthetic	metaphysical propositions	propositions in empirical sciences, such as physics, sociology, etc.

In this scheme, metaphysical claims are regarded as claims about the world whose truth status may be investigated without experience or observation. Formal scientific claims are not claims about the world; their truth status may also be investigated without experience. Empirical scientific claims are claims about the world whose truth status requires experiential or observational investigation.

Most philosophers of science who have labored over the problem of finding an empirical meaningfulness criterion have been trying to find decisive identifying characteristics for empirical scientific claims, to specify the necessary and sufficient conditions for classifying any proposition as worthy of consideration by techniques and personnel they already regarded as scientific. Some fields of study struck these

philosophers as intellectual and practical dead ends, e.g., theology, esthetics, ethics and, worst of all, metaphysics. Some philosophers even claimed that these fields were downright pernicious, that they gave people an unwarranted sense of security and stifled any inclinations toward intellectual progress or social reform. How sweet it would be, they thought, to have an ironclad empirical meaningfulness criterion to bash the brains of the merchants of soporific slush. Even today a scientist may be heard to throw down the gauntlet to the uninitiated: 'That's not scientific!' one may exclaim, as if a knockdown criterion had been found. Alas, it has not been found.

It may be possible not only to waste one's time but to employ it in destructive ways in the interests of worthless fields of study. However, it is doubtful that a principle distinguishing empirical meaningfulness from meaninglessness, empirical science from nonscience, would also serve to separate out worthwhile from worthless fields of study. Insofar as the exclusion of worthless or dangerous investigations was dear to the hearts of those who labored for an empirical meaningfulness criterion, the labor has been in vain. No one has been able to produce such a criterion, and even if anyone had, it would not have been sufficient for the evaluative task.

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Biographical Sketch

Alex is Emeritus Professor in Political Science and Director of the Institute for Social Research and Evaluation at the University of Northern British Columbia. He has published 22 books and over 95 refereed articles, and founded or co-founded 6 scholarly journals. He is the President of the Canadian Commission for UNESCO's Sectoral Commission on Natural, Social and Human Sciences, and a past President of Academy II (Humanities and Social Sciences) of the Royal Society of Canada, and of the International Society for Quality of Life Studies. He was elected Chancellor of UNBC for a 3-year term beginning May 2007. He has won several awards of distinction, including the:

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