Three levels of interaction between science and philosophy

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Published in C. Dilworth (editor), "Intelligibility in Science" (Amsterdam: Rodopi, 1992), pp. 123-144.

The question about the intelligibility of science can be partly translated into the question about the impact of science on philosophy. Indeed, empirical science aims to provide a knowledge which can be submitted to empirical control, and philosophy deals with problems about meaning and intelligibility; therefore, we will obtain a good insight into the intelligibility of science if we determine which is the impact, if any at all, that scientific knowledge has on philosophical matters.

Empirical science consists of three inter-related levels: it is a human enterprise directed towards well defined goals; it employs some characteristic methods in order to achieve these goals; and it produces results that are the objective contents of scientific knowledge. I will consider the impact of science on philosophy in these three levels, that roughly correspond to anthropology (goals), ontology (contents) and epistemology (methods). I will argue that, in each level, science is grounded on some philosophical presuppositions and that, in its turn, has a feedback on them, so that it retro-justifies, refines and enlarges them.

Presuppositions in empirical science can be scientific, if they belong to a discipline and are used as a presupposition of another one, or philosophical, if they are considered as a basis of the entire scientific enterprise. [1] I will focus on the second kind. Furthermore, it should be noted that a philosophical presupposition is not a part of the concrete scientific knowledge as it is expressed in an explicit way; therefore the study of such presuppositions is a philosophical task. We can consider them as conditions that are necessary for the possibility of the scientific activity as such, although they can be ignored by particular scientists. The judgement about their scientific retro-justification, refinement and enlargement obviously requires philosophical insight.

There are general and particular presuppositions in science. Particular or specific presuppositions are, for instance, those related with the use of instruments, the choice of languages, or the frameworks and models of a theory. I will focus on general presuppositions, which are involved in the entire scientific enterprise and are rooted on ordinary and philosophical knowledge. [2] And I will concentrate on those presuppositions that serve to show that scientific progress provides a hindsight about knowledge and truth (epistemological level), nature and natural order (ontological level), and human activity (anthropological level).

I will begin with the epistemological level. What we know best is how science works, and this is why a phenomenological description and a philosophical evaluation of the scientific method is the best way to clarify the impact of science on philosophy. Obviously, the epistemological and the ontological levels are closely related, and it is nature that provides the basis for the scientific enterprise. However, it is easier for us to know our scientific methods than those of nature. Besides, objections against realism

mainly come from epistemological arguments. Therefore it is convenient to begin the examination of realism by considering its epistemological aspects.

1. The epistemological level

It can be safely stated that empirical science searches knowledge and actually reaches it. Whatever may be the interpretation of scientific methods, it is undeniable that science provides us with an extensive knowledge about the composition of matter, the mechanisms of life, and many other features of the real world.

All this points out towards the existence of scientific truth. I will argue that the method of science presupposes a basic gnoseological realism and that this realism is refined and enlarged by the progress of science, so that scientific truth provides a first clue for understanding the intelligibility of science. [3]

This thesis must face an intriguing situation in contemporary epistemology, namely the fact that there is a strong tendency towards relativist and instrumentalist views. Even authors who adopt a realist perspective often argue in favour of a realism of aspiration rather than for a realism of achievement. [4]

Difficulties concerning realism can be summarized in the following chain. First, scientific entities are constructed in the process of theorizing, so that they would not have a mind-independent ontological status. Second, this process of construction would determine the theory-ladeness of any scientific fact; therefore, we could never prove the realist character of our theories. Third, the logical aspects of the hypothetico-deductive method would imply the underdetermination of theories and, as a consequence, the impossibility of assessing the truth of any concrete scientific achievement. Fourth, these features of the scientific method would lead to a fallibilist view that, besides, would be coherent with the provisory character of any scientific construct and would preclude any claim about absolute and definitive truth. And fifth, empirical adequacy could be seen as a sufficient requirement to explain how science works; accordingly, even if positivism is considered as incapable of providing an adequate account of science, it would be not necessary to adopt a realist view in order to do justice to actual scientific practice.

These five difficulties are mutually connected and correspond to real problems. They are grounded on the use of constructions that transcend the realm of experience and include conventions and stipulations. Nevertheless, it is the very use of these stipulations that permits us to formulate intersubjective constructions and proofs that lead to scientific truth. [5]

Indeed, the subject of any scientific discipline is constructed through a method which can be aptly called an objectivation. The scheme of this method can be described in a straighforward way as follows. We cut some pieces of the real world or of hypothetical unobserved realities in such a way that we have a mental cross-section; thus we consider only some aspects and we construct an ideal system which will be the object of our theories. Besides, we relate some of the theoretical entities of this system to the results of real or possible experiments through a set of basic predicates, and we establish some rules in order to interpret that correspondence. Therefore, each objectivation includes ideal and pragmatic features that are inter-related in a precise way. When we have a

well- defined objectivation of this kind, we can proceed through further intersubjective constructions and proofs.

One of the main difficulties in scientific work is to achieve for the first time such an objectivation. Of course, objectivations depend on historical circumstances and evolve with them, and any objectivation includes conventional aspects. Nevertheless, within a concrete objectivation, intersubjectivity is guaranteed provided we proceed with logical rigour. What remains is to ahow how can we pass from this intersubjective validity to stronger claims about realism.

The core of the problem of realism is the notion of truth. Difficulties necessarily arise if we think about truth as a qualification that could only be applied to something totally independent of our abilities to know and of our active intervention; if this were the case, we could never institute a meaningful talk about truth. But we can do it provided we realize that truth primarily is a qualification of our knowledge, and that this knowledge can be called true if what we assert corresponds with the real situation which we intend to reflect. Then, truth is always relative to a particular perspective that includes theoretical and pragmatical features, and this amounts to saying that truth is contextual. However, once we have established a well-defined context, we are no longer free to interpret claims to truth in a subjective way.

Does this mean that we can only achieve a contextual truth? In this case, truth would mean only coherence and there would be no problem about realism. Even the most strong opponents to the idea of scientific truth would admit that we often reach rigorous proofs; nevertheless, they will argue that proofs are rigorous only within a given presuppositional framework and that, therefore, we can only speak of truth as consisting in relations of coherence. What is then at stake is the possibility of passing from a coherence notion of validity to a correspondence notion of truth.

The way of doing this can be summarized as follows. Once we have established the intra-contextual validity of a construct, which includes intersubjective ways of correspondence with empirical situations, if this construct can be successfully applied to solve concrete problems, this will determine its truth value. We should only be aware of the diversity of meanings and proofs, as obviously we do not mean the same thing when we apply the notion of truth to a general principle and to a concrete spatial structure.

This can be explained in other words. The intersubjective validity of a theoretical construction can be contextually fixed within a concrete objectivation. If we succeed when we submit it to empirical control, then we can apply it for solving factual problems, and we can establish its pragmatical value. Then, if contextual and pragmatical validity are well established, the correspondence with reality will be automatically established. Indeed, constructions which are valid under some theoretical and practical conditions, will correspond to reality in the precise sense indicated by these conditions.

Therefore we can speak about a scientific truth which is contextual and therefore is also partial and approximative. And this implies that it is perfectible; that it must be conceived as having a somewhat different value according to the different modalities of constructions and proofs; and that it has a historical dimension, because any context is defined by using constructions that depend on historical conditions.

This explanation of truth combines the contextual, the semantic and the pragmatical features, which correspond to the theories of truth as coherence, as correspondence and as praxis. We will find unsolvable problems if we separate these features. [6] This would happen, for instance, if we try to establish truth as a correspondence conceived as complete independence of theoretical construction and pragmatical intervention. An interpretation of this kind would amount to an illegitimate absolutization of truth, because the value of our knowledge would be considered as if it were independent of our concepts, of their references and of the real problems which we try to solve. Instead, our explanation of truth takes into account these dimensions of our real knowledge.

The relative aspect of truth, such as has been explained, is actually innocuous, and does not involve any relativist consequence such as subjectivism or scepticism. It could be compared with the relative which, in the theory of relativity, has well-defined values in any framework. Obviously, we must be always aware of the framework we use in each particular case but, however difficult this task may be, we are able to achieve it. We will never reach a complete knowledge, but we can at least obtain a general perspective about the particular perspectives we use.

All this can be used to explain the real problems that seem to provide foundations for anti-realist views. Our knowledge is rightly seen by relativism as framework-dependent; by fallibilism as limited and perfectible; and by instrumentalism as connected with pragmatical problems. But these views extrapolate these real features of scientific knowledge, and the result is that they fail to reconcile them with the undeniable fact that we achieve a true knowledge about reality. Instead, the notion of truth can be applied not only as a regulative idea, but also in a concrete way, if we realize that in actual scientific practice the contextual, referential and pragmatical features of truth are inter-related.

For instance, fallibilism sees the method of science as progressive insofar as we can find falsities in our theories, so that considering a theory as true would be anti-progressive dogmatism. Thus, it is hardly understandable how we can achieve positive knowledge. Fallibilism is largely widespread in contemporary epistemology. Even authors who criticize anti-realist views proclaim their adhesion to it. [7] However, the thesis of fallibilism can easily lead to confusions. In its original context, it "arises from a critique of the solutions of epistemological problems offered by the rationalist tradition", and results "from the impossibility of maintaining the fusion of truth and certainty implied by classical rationalism." [8] But then, what should be done is simply to abandon classical rationalism.

Construction and control, such as they are used in empirical science, presuppose a realist perspective. Theoretical constructs refer to real situations and are used to explain them, and methods of empirical control serve to prove the explanatory claims of theories. An anti-realist perspective would fail to account for the real achievements of scientific method and even for its fallibilist aspects.

The realism presupposed by the scientific method is only a basic one that does not involve many specific philosophical consequences. It is centred around the possibility of obtaining a true knowledge about reality. The analysis of the method of science shows that this method basically corresponds to the realist character of ordinary knowledge. Furthermore, it shows how that basic realism can be refined and enlarged.

The refinements refer to the subtleties involved in scientific practice. Indeed, it is easily recognizable that, in actual scientific practice, the empirical and theoretical aspects are intertwined in such a way that both empiricism and rationalism fail to explain how science works. Also, pragmatism fails to account for the results that we obtain. All this suggests that further examination of the scientific method may provide important insights about human knowledge and also about the philosophical problems related to it.

We can also speak of an enrichment of realism. The progress of science implies that our knowledge has been and continues to be enlarged to an astonishing degree. And this refers not only to concrete pieces of information, but also to the exercise of our abilities. The subtleties of the method of science are not established once for all; as science progresses, they are expanded and applied in new ways. Creativity is a substantial part of the scientific method, not only because we construct theories that transcend the available data, but also because the ways of relating ideal constructs with empirical data require the exercise of a most creative way of reasoning. Even the work performed to obtain empirical data usually is a very creative one, as it requires imagination and skill.

All this means that empirical science is a most relevant factor in order to understand how we know, to evaluate our notions of truth and realism, and therefore to examine intelligibility in general. This conclusion is grounded on the existence of scientific truth and on the analysis of the scientific method, which shows how we achieve scientific truth through a very subtle method which combines idealization and experiments.

We would arrive at a different perspective if we did not hold the possibility of achieving concrete true pieces of knowledge. This is why some defences of epistemological realism, although they proclaim that "the quintessentially cognitive aspiration of getting at the truth about the world's ways is the very essence of scientific enterprise", and that "abandoning of the pursuit of truth as a regulative ideal would hamstring from the very outset the scientific project of rational inquiry into nature", do not propose convincing arguments for a realist view that goes beyond the merely subjective aims. [9] Then, the intelligibility of science should lead to an image very different from the one that results when we admit the possibility of achieving concrete true knowledge.

For instance, it is not surprising that, according to the fallibilist tradition, the main problem of epistemology should be that of understanding the continuity between human and animal knowledge, in such a way that the doubt sometimes remains about their possible discontinuities. [10] If the method of science is identified with the method of trial and error elimination, and at the same time it is accepted that this method coincides basically with that employed in animal knowledge, further claims about rationality and truth, although they be sincere and correct in themselves, cannot have an adequate foundation. Then, the resulting picture of the intelligibility of science will be full of problems, although it may be accompanied by strong claims about the peculiarities of critical thought.

2. The ontological level

The existence of a natural order is already presupposed in ordinary knowledge. Truth in scientific knowledge also presupposes a natural order which provides the basis to formulate laws and to control them through repeatable experiments. Therefore, the

preceding reflections about scientific truth can already be seen as a proof of the claim about a realist ontology.

The idea of order mainly consists of two aspects, namely regularity and coherence. We may think of regularities at different levels of entities and processes, whilst coherence means that these levels are inter-connected in such a way that they form a unitary whole.

To qualify order as natural means that it has its own consistency, which cannot be reduced to subjective characteristics such as the need to postulate regularities in order to formulate explanations.

The scientific enterprise is based on the supposition that there exists a natural order in deeper levels that are not accessible to ordinary knowledge, and also supposes that we are able to know it.

That the method of empirical science presupposes a realist ontology can be easily admitted. Indeed, the method of construction and control supposes the existence of a mind-independent reality because, without this assumption, it would be meaningless to contruct theories to explain factual problems, to connect the theories with factual data, to perform experiments in order to test theories, and to correct theories when they are not coherent with the factual results. Therefore, natural order is not a merely regulative idea that makes possible the scientific quest. The scientific method of construction and control is effective, and this implies that we deal with a real existing order.

All this can be expressed as 'methodological realism', because it expresses "the reasoning involved in research, theoretical and experimental", and "does not rest on intentions or beliefs of the researcher", as does a realism that limits itself to assert that theories must have a referential interpretation. [11] These arguments show that the method used in empirical science could not be applied if we did not admit an ontological realism.

The same idea can be expressed as 'the explanatory power of realism.' Anti-realist interpretations cannot explain why some theories are successful and others fail; "realism then, and the idea of truth attached to it (the correspondence theory of truth), are distinguished by their explanatory power". This argument supposes that we can apply the criterion of explanatory power to evaluate philosophical interpretations. [12]

Why not? One possible objection would be that we cannot put at the same level the success of empirical science and its philosophical interpretations. However, this objection can be solved if we note, on the one hand, that the distinction between the two levels remains untouched in the argument, and on the other, that the argument has an undeniable logical weight. Indeed, if something must be considered as a necessary condition for the very existence of something else, and the latter really exists, then we must admit also the real existence of its necessary condition. [13]

The heuristic power of ontological realism is another argument in its favour. We can argue that "positivism, relativism and instrumentalism must justify or motivate their methodological rules by arguments independent of ontology. This will not always be possible. Why should we look for quarks, for black holes, if they were nothing but

useful concepts, helpful fictions, efficient instruments? We never look for something whose existence we deny. Thus, ontological realism is heuristically much more fruitful than any other position." [14] Doubtless, the efficiency of this heuristic power can be illustrated in many real cases. However, this argument is weaker than the previous one, because a pragmatically-oriented epistemology can provide methodological rules similar to those of realism; only, it will consider the unobserved entities as efficient tools to achieve the pragmatical goal of science.

That scientific progress retro-justifies the realist views about the existence of a natural order can be illustrated by considering some features of scientific achievement. Indeed, scientific constructs can be always seen as ways towards unification, and the scientific pictures represent the world as the result of the interaction and integration of patterns. Thus, the more science progresses, the more we can look at nature as an orderly structured reality.

Actually, scientific laws are means to unify different features of nature; for instance, particular empirical laws express regularities that unify different phenomena, and general laws or principles unify different kinds of phenomena. Also, theories unify one or several ambits of phenomena under some general principles and laws. The historical record shows that scientific achievements always mean a progress towards unification; the first empirical laws that serve to constitute a new discipline are later inter-connected by means of general laws that explain them, and further progress connects several existing theories in frameworks that are increasingly comprehensive.

One of the most remarkable achievements of science is the discovery of patterns. It is possible to say that "if we were to describe the fundamental property of the matter of the universe in a single sentence, we would have to say that matter is formed -or created- so as to show continuously accelerating growth of patterns." [15] After all, this should not be surprising at all because matter always exists embodied in some pattern and, if we try to achieve a better knowledge of nature, we should expect that new patterns will always emerge. However, elementary as this remark may be, it shows that the expectations involved in the ontological presuppositions about natural order are fulfilled in an increasing measure as science progresses, and this may be considered as a retro-justification of these presuppositions.

This also has as a consequence a refinement of our ideas about nature. Scientific pictures provide us with reliable representations that supersede ancient world-views, and this fact has had and even now has deep implications on philosophical world-views. This is why, even if one asserted that empirical science only reaches some kind of factual knowledge, this would not mean that science does not provide relevant insights on human affairs.

Furthermore, science enlarges our ideas about nature. We reach a knowledge of patterns at different levels and we are able to connect them in unified views. Matter appears basically patterned, and every pattern is the result of the interactions between elements. The organistic and mechanistic pictures of the world have been substituted by a systemic perspective in which the formerly antagonist features of nature are reconciled. And the synchronical picture is completed and partially explained by a diachronical picture that permits us to understand how patterns originate and grow.

Obviously, this picture is by no means complete. The evolutionary world-view must face a difficult task, namely that of providing morphogenetic theories that may explain how new levels emerge out of other more basic ones. In this context, problems about emergence and reduction occupy a central place.

The difficulties of the classical analysis of reductionism, where reduction was treated as logical deduction of laws or theories, [16] suggest that the problem of reduction should be replaced by that of the relations between levels. With respect to homogeneous theories, it has been pointed out that reductions by logical derivation seldom occur or that they are even impossible; a weak or instrumentalist reduction would be possible, but this reduction would only mean a partial and approximate coincidence of results. Strong reductions between heterogeneous theories would also be possible, but only in the sense that the reduced theory could be retained and even better corroborated. The conclusion is that it would be convenient to substitute the very term 'reduction' by those of 'quasi-reduction' or 'partial explanation, ' to stress the difficulties of a full reductionism. [17] Now it is generally accepted that, if actual scientific practice is properly taken into account, what reduction really means is establishing partial connections between different epistemological levels, and that these connections may adopt very different modalities. [18]

The possibility of formulating morphogenetic theories that relate different levels depends on the existence of a hierarchy of inter-related levels. But difficulties also arise from the limits of our knowledge and from the respective need of adopting partial points of view. Actually there are different epistemological levels [19], and even a plurality of ontologies that are implied by the different theories and usually are not replaced when some deeper theories are formulated. [20] All this is already important when applied to the analysis of the very first level of physical theories, and even more when we study the relations between physics and chemistry. [21] Even greater are the difficulties when we consider the relations between the physico-chemical and the biological levels, so that explanations expressed through physical sciences neither eliminate nor make useless the epistemological levels of biology. [22]

The preceding reflections refer to relations between theories that belong to the same level or to adjacent levels. Greater even are the difficulties when the results of one level are used to explain problems that belong to more distant levels. This is the case of some theories that usually are labelled as morphogenetic, namely non-linear thermodynamics, synergetics, catastrophe theory and theories about chaos.

Non-linear thermodynamics shows that biological processes may be compatible with the second law of thermodynamics; it suggests that in open systems, far from equilibrium, biological structures can arise through amplification of fluctuations that lead to a new state in which dissipative structures can be maintained. Doubtless, this is interesting from the morphogenetic point of view; nevertheless it can be said that also in this case there is neither logical reduction nor elimination of properly biological levels. [23] Synergetics, catastrophe theory and theories about chaos intend to relate levels that are not only different, but even in many cases are far away from each other; this is why it is very difficult to establish in a rigorous way the general validity of the models that they provide. From the morphogenetic point of view, the main interest of those theories is an heuristic one, as they suggest the existence of similarities in patterns that may be found in different levels.

If there are such difficulties in the epistemological level, it is understandable that the problem of ontological emergence poses even greater difficulties. Nevertheless, the progress towards unification is one of the main regulative ideas of the scientific enterprise. Great as may be the difficulties of achieving a complete unification, many positive results have already been achieved, and they provide a basis to assert that the progress of science enriches in a great extent our previous ideas about a natural order that increasingly discloses itself to our scientific quest.

It can be also argued that all this presupposes, refines and enriches the classical idea of nature as an internal principle of activity, and that an examination of this idea, that is implicit in that of natural order, can provide a better understanding of the intelligibility of nature. [24] In this way, the intelligibility of science provides important clues for the development of natural philosophy.

3. The anthropological level

The scientific enterprise, as a quest for knowledge that can be submitted to empirical control and used for practical purposes, can be easily seen as grounded on the general human interests about knowledge and action. It is also evident that the scientific progress enlarges the possibilities of achieving these goals. Under this perspective, the intelligibility of science consists in its being a means to achieve true knowledge and practical dominion of nature. Therefore, also in this level we can say that the anthropological presuppositions of science are retro-justified, refined and enriched by scientific progress.

Further claims about the relevance of science in human life will depend on particular views about the meaning of human life. In this context, the most fundamental question is to determine which is the role, if any at all, that empirical science plays in problems about transcendence.

What has been said about objectivity shows that any scientific construct must be always interpreted within a particular objectivation and that, therefore, the scientific method leaves room for a quest directed to the study of the radical conditions of being, truth, goodness, beauty, ethical duties, and transcendence. [25] Also, whatever the merits of a particular piece of natural theology may be, there will always be a methodological gap between empirical science and the quest for transcendence.

According to scientific naturalism there should not be such a gap, as scientific method is seen as the only legitimate one. However, as Ian Barbour puts it, this view wrongly assumes that there is only one acceptable type of explanation; then, particular scientific concepts are extended and extrapolated beyond their scientific use, so that they are inflated into comprehensive naturalistic philosophies; and the abstractive and selective character of science is ignored, falling into that which Whitehead calls "the fallacy of misplaced concreteness." [26]

Naturalism gratuitously turns the difference of methods into contradiction, by denying the truth or correctness of any approach that does not coincide with the scientific one. Naturalism often asserts that, as a matter of fact, the arguments of natural theology are more and more pushed aside by the progress of science, so that it would be legitimate to conclude that one can get rid of transcendence. By shifting to the questions of fact,

naturalism can easily find favourable exemples; nevertheless, this move leaves the methodological problem untouched. Moreover, the alleged replacement of theological explanations by scientific ones often corresponds to a lack of philosophical insight; this happens, for instance, when natural agency is seen as incompatible with that of a transcendent God.

Therefore, it seems undeniable there is a methodological gap between empirical science and the questions about transcendence. Is that all? Actually, we find many controversial issues about this subject. Does this mean that the methodological gap only expresses a first approximation that must be completed by considering the positive relations that exist between the two approaches? If this were the case, how could we conceive that two mutually independent approaches may interact with one another?

It is often said that science leads to boundary questions that are connected with theology, [27] so that "there are questions which arise from science and which insistently demand an answer, but which by their very character transcend that of which science itself is competent to speak." [28] But, what does the statement that they 'arise from science' mean? This should mean that they begin to exist as a consequence of something that is scientific, or that they are caused by it. What is then difficult to understand is how this can happen. Which kind of reasoning would allow us to bridge the methodological gap?

Two different kinds of problems may be distinguished in this context. The first kind includes particular scientific problems that allegedly would connect with questions about transcendence; I will try to show that they can only be a subjective source of questions about transcendence. The second kind refers to the general presuppositions of science and to general insights on its achievements, and they can be better considered as boundary questions.

With respect to problems of the first kind, John Polkinghorne says that there is "a widespread feeling among practising scientists, particularly those of us who have worked in fundamental physics, that there is more to the physical world than has met the scientific eye. As a result of that feeling, we are living at a time when there is a revival of natural theology taking place, largely at the hands of the scientists rather than the theologians." [29] To illustrate his assertion, Polkinghorne refers to Paul Davies. [30] However, Davies argues for a kind of pantheism that is related with the idea of a self-creating universe that would have come spontaneously into existence, and he presents his ideas as 'the physicist's conception of nature'; actually, Davies uses a dubious philosophy that is presented as if it were a mere application or a consequence of physics. [31] Indeed, the questions discussed by Davies are the classical ones of natural theology; only, Davies uses arguments connected with science in order to answer them. Therefore, it is not clear, to say the least, that we are here dealing with real boundary questions.

Cosmology has been, in the last decades, a source of alleged boundary questions. Theologians usually agree that cosmological arguments can neither proof nor disprove the Christian doctrine of creation. [32] But there is also an inflationary bibliography supporting the idea that "there is sufficient evidence at present to justify the belief that the universe began to exist without being caused to do so." [33] However, as intriguing as quantum fluctuations and quantum gravity may be, there is little rigour when the

metaphysical problem of the creation out of nothing is considered as a physical one. Indeed, then we would not deal with a boundary question, but with a reduction.

The cosmological anthropic principle is sometimes presented as another boundary question. Nevertheless, it seems better to consider it as a new instance of a well-known situation, namely the tendency that scientists have to establish a link between metaphysical questions and their scientific concerns. In this line, we can find as many boundary questions as we desire, but this would not serve as an answer to the central problem. Science may be seen as a catalyst to set off metaphysical attitudes, but this does not mean that science by itself implies any metaphysical problem at all; rather, it adopts a non-metaphysical point of view. In short, I wonder if any specific problem that can be formulated within empirical science may be seen as a boundary question.

Instead, general presuppositions and insights can be seen as real boundary questions, and this is especially true in the case of intelligibility. Thus, Polkinghorne speaks of 'insight' as "a way of looking at the totality of things which has coherence and intelligibility", and asserts that, in this respect, "theism offers a more satisfying and more extensive explanation of what is going on." [34] He also refers to "the curious way in which modern science seems, almost irresistibly, to point beyond itself." [35]

However, using general presuppositions as a way from science to transcendence requires a long journey. Indeed, it is difficult to prove that particular ideas about transcendence may be seen as necessary conditions of scientific reasoning or of particular achievements. And, even if we could conclude that there are some general metaphysical conditions of science, this could be connected with different views about their ultimate foundations.

The historical approach to these questions continues to feed interesting debates. Stanley Jaki argues that the scientific enterprise had repeated stillbirths due to the organistic and pantheist worldviews of ancient cultures, and that it found its only viable birth as a self-sustained enterprise within a Christian cultural matrix which permeated an entire culture for several centuries, providing a solid foundation for the ontological and epistemological bases that were needed if the scientific work was to have any meaning at all. [36] He also argues that these bases continue to be a condition, at least an implicit one, for any truly creative science; [37] and further that they coincide with the realist bases of the classical proofs of the existence of God. [38]

As far as these theses are mainly centred around the historical perspective, they refer to contingent facts. Nevertheless, they also allude to systematic problems such as those of epistemological and ontological realism. If realism can be retro-justified by the 'wisdom of hindsight' on grounds of its pragmatical and explanatory efficacy, [39] this hindsight may be connected with the insight that leads towards transcendence. Indeed, nature discloses itself to scientists as power, life, order and unity; and this provides a hint about transcendence that, anyway, must be studied from a strictly philosophical and religious point of view. [40]

Another different interaction is the use of scientific knowledge within metaphysical arguments. Among the questions that are usually considered as boundary, many belong to this category, and they could be better labelled as 'particular overlappings.' The usual

case of overlapping is that of pieces of scientific information that are used as a part of the proofs of the existence of God or in arguments about the attributes of God.

Theologians rightly aim to emphasize that it is unsound to argue in the line of the so-called 'God of the gaps, ' and they admit that only metaphysical arguments have a chance of succeeding. There is also a clear awareness about "the extreme fluidity whereby models of nature designed to highlight divine activity have so readily lent themselves to reinterpretation in secular terms." [41] In this line, as already noted, theologians usually consider arguments such as the fine-tuning of the universe as compatible, coherent or consonant with theism, and not as real proofs of it. [42]

Scientific information can be used within natural theology in the same way as any other information. However, it should be first submitted to epistemological evaluation, and this is a non trivial problem. Furthermore, we should also reflect philosophically on it; indeed, only philosophy is homogeneous enough with natural theology, whereas empirical science is not. The methodological gap between empirical science and natural theology is all-pervasive. It is possible to bridge it; but the bridge must include philosophical reflections that, although they should be coherent with science, cannot be considered as a mere consequence of it.

Then, the quest for integration will depend on our general philosophical and theological views and, although these views can be submitted to rational consideration, they necessarily include personal commitments. In any case, it can be safely stated that empirical science makes sense insofar as it is seen as a quest for truth and as a source of means for the service of mankind. Although this view is fully coherent with the monotheist tenets about God, creation, nature and mankind, further progress in the quest for integration would require using arguments that go far beyond the scientific and epistemological perspectives.

That empirical science requires a complement of philosophical insight in order to face the deepest human problems should not be interpreted as an undervaluation of the intelligibility that empirical science provides us with. It merely reflects the fact that scientific intelligibility, although it possesses its own ambit of autonomy, is the result of developing the possibilities of human rationality and should be integrated within it.

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Notes

(1) Some useful and debatable distinctions about the presuppositions of science can be seen in Pap (1949), pp. 402-408.

(2) The presuppositions which Kurt Hübner considers as aprioristic and historical conditions of science can be considered as particular presuppositions. Indeed, although every discipline must rely on instrumental, functional, axiomatic and judicative assumptions, these are different in each discipline. The only kind of assumptions that could be considered as general would be the normative ones, that function as a criterion of demarcation. Cf Hübner (1978) and (1985).

(3) Larry Laudan concludes that "given the present state of the art, it can only be wish fulfilment that gives rise to the claim that realism, and realism alone, explains why science works": Laudan (1981), p. 48. However, I do not claim that realism explains why science works; I only consider it as a necessary condition. For a defence of methodological realism cf Leplin (1986), where it is argued that "certain realist assumptions are crucial to the rationality of research". Bas van Fraassen argues that empirical adequacy is the only requisite for the acceptance of theories: cf van Fraassen (1980), p. 12 and passim; van Fraassen's views are criticized in Leplin (1986), pp. 33-44.

(4) For a critical examination of several contemporary relativist views, cf Siegel (1987).

(5) For a systematic treatment of the notion of scientific truth, cf Artigas (1989), where I argue for a perspective that basically coincides with the objectualist realism elaborated by Evandro Agazzi. For Agazzi's ideas on this topic, cf Agazzi (1969), (1978), (1986) and (1988). A general outlook on Agazzi's epistemology, its roots and its applications is Rossi (1986). I have compared my views with those of Agazzi in Artigas (1988).

(6) This point is stressed in the 'internal realism' of Hillary Putnam: cf Putnam (1988), pp. 113-116.

(7) This is the case of Siegel and Rescher: cf Siegel (1987), p. 113, and Rescher (1987), p. 33. Siegel's adhesion to fallibilism is significative, because it is asserted as a point of agreement with Harold Brown, in spite of Brown's commitment to a pragmatical notion of truth that was abandoned under the critiques of Siegel: cf Brown (1977), p. 151-153, Siegel (1983) and Brown (1983). Rescher's adhesion to fallibilism also comes in a context in which he argues for realist positions.

(8) Albert (1987), pp. 69-70.

(9) Cf Rescher (1987), p. 33. The reason of these shortcomings can be found in the same place, when it is said that "we must accept a fallibilistic view of science". Whilst a weak interpretation of fallibilism would only mean that scientific truth is partial and therefore perfectible, the stronger version asserts that we can never obtain true knowledge; then, the task of seriously defending realism becomes a very difficult one.

(10) "The main task of the theory of human knowledge is to understand it as continuous with animal knowledge; and to understand also its discontinuity -if any- from animal knowledge: Popper (1974), p. 117. However, at the end of this essay (p. 120), Popper stresses the unique character of human ability of critical reasoning as compared with the abilities of animals, and gently complains that this is not explicitly expressed in the essay of Donald Campbell which is the subject of his comments.

(11) Cf Leplin (1986), p. 32.

(12) Cf Vollmer (1987), p. 188.

(13) In my opinion, this argument has more weight than Vollmer thinks. He argues in favour of "any form of realism (be it critical, scientific, convergent or hypothetical realism)" and against positivism, relativism and instrumentalism, and he uses his argument to show the "advantages" of ontological realism, so that realism "is to be preferred" to the other interpretations: cf Vollmer (1987), p. 187-188. Although I agree with this, I think that the argument can be also used for a realism that is stronger than the hypothetical one which is defended by Vollmer in other works.

(14) Vollmer (1987), p. 188.

(15) Cf Bresch (1987), p. 36.

(16) Cf Nagel (1961), pp. 336-397.

(17) Cf Sklar (1967); Darden - Maull (1977); Friedman (1982).

(18) An interesting account of these problems is provided in the essays collected in Radnitzky (1988).

(19) Cf Kanitscheider (1988).

(20) Cf Rohrlich (1988).

(21) Cf Primas (1988).

(22) Cf Kitcher (1982) and (1984); Rosenberg (1985), pp. 69-120.

(23) Cf Friedman (1982), pp. 28-39.

(24) William Wallace has articulated this connection between the Aristotelian notion of nature and the achievements of empirical science: cf Wallace (1984).

(25) Evandro Agazzi convincingly shows that this is a consequence of the characteristics of scientific objectivity: cf Agazzi (1987).

(26) Cf Barbour (1988), p. 25.

(27) This claim is sustained by many authors: for instance, cf Barbour (1988), p. 33-37; Russo (1982), pp. 96-97.

(28) Polkinghorne (1990), p. 88.

(29) Polkinghorne (1990), p. 88.

(30) He alludes to Davies (1983).

(31) The basic views of Davies are analyzed in Craig (1986), Artigas (1987) and Carroll (1988).

(32) Cf Jaki (1982), p. 260; McMullin (1981), p. 39

(33) Smith (1988), p. 39.

(34) Polkinghorne (1990), p. 89.

(35) Polkinghorne (1986), p. 63.

(36) Cf Jaki (1974).

(37) Cf Jaki (1986), pp. 161-181.

(38) Cf Jaki (1978).

(39) Cf Rescher (1987), p. 126.

(40) Cf Gilkey (1989).

(41) Brooke (1989), p. 16.

(42) Cf McMullin (1988), p. 70-71; Clarke (1988), p. 103-104.