The Xavier Zubiri Review, Vol. 11, 2009, pp. 91-106

Naturalism and Science[1]

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Abstract

"Naturalism" has been used as a means to distinguish the scientific from the non-scientific. Methodological naturalism emphasizes the fact that only natural entities can be employed in scientific theories. Metaphysical naturalism goes beyond this and affirms that only those things that are naturalistic are real. In fact, naturalism is the product of two more fundamental notions: the canon of reality and the scientific method. Since neither of those can be defined in an unambiguous and unchanging manner, naturalism also is fundamentally blurry. There is therefore no hard-and-fast distinction between the category of naturalistic and that of non-naturalistic; they blend together in a complex manner, even if, in particular cases, with respect to particular entities, they are functionally quite distinct.

Resumen

"Naturalismo" se ha usado como un medio para distinguir lo científico de lo no-científico. El naturalismo metodológico da énfasis al hecho de que sólo pueden emplearse entidades naturales en teorías científicas. El naturalismo metafísico va más allá de esto y afirma que sólo las cosas naturalistas son reales. De hecho, el naturalismo es el producto de dos nociones más fundamentales: el canon de la realidad y el método científico. Puesto que ninguno de aquéllos puede definirse de una manera inequívoca y inmutable, naturalismo mismo también queda fundamentalmente borroso. Por consiguiente no hay ninguna distinción dura la categoría de naturalista y la categoría de no-naturalista; ellos mezclan juntos de una manera compleja, aun cuando, en casos particulares, con respecto a las entidades particulares, ellos sean funcionalmente bastante distintos.

Introduction

One of the most vexing and pernicious aspects of science in general and the evolution controversy in particular is the tendency to make evolution and, by extension science, into general explanatory paradigms encompassing and/or supplanting philosophy, art, religion, and most other fields of human knowledge. The level of conceptual confusion inherent in this position is so great that sorting it out and clarifying just what science is and can do is a daunting task. The task is made more difficult by the pervasiveness of this belief in our society, and the fact that such a a belief self-referentially but illicitly converts science into something "too big to fail". Real science may be sufficiently well established that its failure is exceedingly unlikely; but the same cannot be said of philosophical or other systems erected upon it. One root of the problem lies in the concept of "naturalism". Science is supposed to be "naturalistic", and this is often taken as its defining characteristic. Just what is "naturalism"? What is "naturalistic"? It is, lamentably, too many different things to too many people. Nonetheless, let us attempt to unravel the complex mess that this concept involves.

A. What is Naturalism?

We shall begin by examining some typical definitions or explanations of Naturalism:

> If there is one rule, one criterion that makes an idea scientific, it is that it *must* invoke naturalistic explanations for phenomena, and those explanations must be testable solely by the criteria of our five senses.[2]…scientists are constrained to frame *all* their statements in "naturalistic" terms simple to be able to test them.[3]

This defines "naturalism" only implicitly, of course. The following attempts to be more explicit:

> Most scientists today require that science be carried out according to the rule of *methodological naturalism*: to explain the natural world scientifically, scientists must restrict themselves only to material causes (to matter, energy, and their interaction). There is a practical reason for this restriction: it works. By continuing to seek natural explanations for how the world works, we have been able to find them. If supernatural explanations are allowed, they will discourage—or at least delay—the discovery of natural explanations, and we will understand less about the universe.[4]

Still another formulation—again indirect—is the following:

> …the most important characteristic of modern science is that it depends entirely on the operation of blind, unchanging regularities in nature. We call those regularities "natural laws." Thus, scientists seek to understand the empirical world by reference to natural law and naturalistic processes.[5]

Let us examine some of the ideas presented here. We may enumerate them as follows:

1. Naturalistic explanations utilize only material causes (matter, energy, interactions of them)
2. Naturalistic explanations involve only the five senses.
3. "Naturalistic" and "naturalism" are opposed to (disjoint from) "supernatural".
4. There is a hard-and-fast distinction between the scientific and the non-scientific, both in object and methodology
5. Science does not allow nor is it involved with the "supernatural".
6. Supernatural explanations of phenomena do not contribute to our understanding of the universe
7. In at least some cases, either natural or supernatural explanations are possible.

These quotations reveal aspects of naturalism that are critical for our investigation. To that we turn next.

B. Why is naturalism important?

As the quotations make clear, naturalism is often regarded as the key component of scientific explanation, what makes a theory or statement "scientific". This is important because in theory it allows us to "wall off" science from other knowledge, keep it pure, and ensure that it is concentrated on what it is designed to do, namely determine how nature works. Without naturalism, science can easily stray or degenerate into metaphysical speculation. The further removed science is from direct contact with experiment, the more readily this occurs. By insisting on naturalism, so the thinking goes, this can be prevented, and metaphysical contamination of science avoided.

Thus naturalism is important because it is the salient characteristic separating science from all other forms of knowledge about the world. Naturalism can thus be used to focus science on its mission, to train scientists, and to ward off poachers—those who seek to co-opt the prestige of science for non-scientific purposes. All we need to do, therefore, is devise a suitable

unambiguous definition of naturalism. By observing how science works, what it accomplishes, what assumptions it makes, and what types of explanation it allows, it should be possible to define naturalism in a suitable way.

At least, this is the theory. In reality, as we shall see, naturalism is a derivative concept, based on two more fundamental conceptual structures, the *canon of reality* and the *scientific method*. Naturalism is the product of a particular way of going about the acquisition of knowledge, viz. the scientific method, constrained to work on a certain group of entities, those allowed in the canon of reality, or at least the canon of scientific reality. This relationship, which will be analyzed in this paper, is illustrated in Figure 1. Therefore an understanding of naturalism requires an understanding of its components, and already naturalism is becoming more complicated than perhaps it appeared at first sight. Before beginning the task of analyzing naturalism's components and how they work together, we need to review the two types of naturalism, how they have been used, and what assumptions they make.

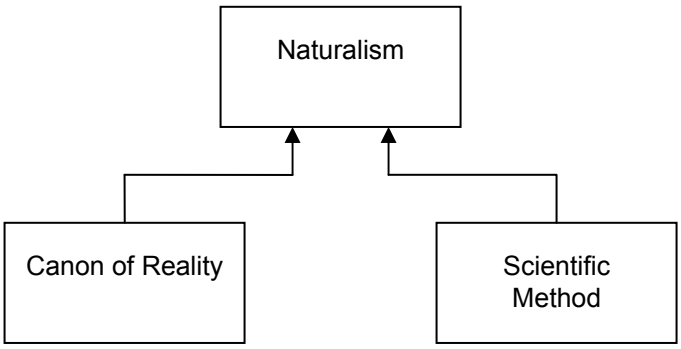

Figure 1. Genesis of Naturalism

C. The two types of naturalism: distinction between "methodological naturalism" and "metaphysical naturalism"

In many discussions of naturalism and science there lies a distinction that is often suppressed or ignored, that between *methodological naturalism* and *metaphysical naturalism*. In essence, *methodological naturalism* states that, as a practical matter, science can only utilize explanations that involve operationally definable quantities such as mass, energy, time, and so forth. (This is easier said than done, but we shall ignore that problem for now.) Thus methodological naturalism is about the way science actually works, especially the types of explanation it can use, the acceptable range of things these explanations employ, and the logic involved in drawing conclusions that are acceptable scientifically.

At first glance, this would seem to be adequate since it gives the scope of science and meets the other goals set for naturalism. But science does seek to tell us something about reality; and metaphysics, defined as thought or explanation about reality in the deepest sense, is not easily marginalized. In fact science does sometimes deliver new reality to us: we now know about elementary particles, genes, quasars, black holes, and dark matter because of science. Partly because of this, it is but a short step from claiming that science must be based on naturalism or naturalistic statements, to saying that *only* naturalistic phenomena exist. So if science cannot explain or describe something, it does not exist. This is *metaphysical naturalism*, because it draws conclusions about reality, about what exists.

Metaphysical naturalism goes far beyond methodological naturalism and states that only "natural" things exist. As usually interpreted, it states in effect that the "supernatural" does not exist, and that all explanations of phenomena can be made by means of explanations that fall under the category of methodological naturalism. This metaphysical assertion cannot be a result of science; it is a distinctly philosophical position which must be justified on non-scientific grounds. It is, in fact, a radical form of *reductionism*, the doctrine that all phenomena and the underlying reality can be reduced to whatever it is that particle physics studies.

Unfortunately metaphysical naturalism is often proffered as a scientific conclusion or an inference from science, without explicit acknowledgment of its philosophical—not scientific—status and pedigree. Obviously, both methodological and metaphysical naturalism assume that there is a way to determine what is natural and what is not. That, unsurprisingly, is not so easy to do. Nonetheless the overriding goal of dismissing all non-scientific knowledge and entities is very strong, as the following quotation, which has achieved virtual iconic status, makes clear:

> We take the side of science in spite of the patent absurdity of some of its constructs, in spite of its failure to fulfill many of its extravagant promises of health and life, in spite of the tolerance of the scientific community for unsubstantiated just-so stories, because we have a prior commitment, a commitment to materialism. It is not that the methods and institutions of science somehow compel us to accept a material explanation of the phenomenal world, but, on the contrary, that we are forced by our *a priori* adherence to material causes to create an apparatus of investigation and a set of concepts that produce material explanations, no matter how counter-intuitive, no matter how mystifying to the uninitiated. Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door. The eminent Kant Scholar Lewis Beck used to say that anyone who could believe in God could believe in anything. To appeal to omnipotent deity is to allow that at any moment the regularities of nature may be ruptured, that miracles may happen.[6]

But what if the crucial assumption is not true? What if naturalistic explanations *cannot* explain all observed phenomena? What if they reach a barrier? Nothing about scientific theories or explanations guarantees that they can explain everything. If they cannot, scientists would continue unperturbed in their work, but not those seeking to use science to advance extra-scientific claims. This is an extremely important point—why do we not hear more about it? Indeed, it forms the real basis for the arguments of the Intelligent Design school. At least one important scientist, Steven Weinberg, has recognized the problem, and it is perhaps significant that he is a physicist and not a biologist:

> The only way that any sort of science can proceed is to assume that there is no divine intervention and to see how far one can get with this assumption.[7]

But while this point is well-taken, it really overlooks the more immediate problem of the naturalistic/non-naturalistic distinction. We can forget about divine intervention for the time being, and simply ask if science can in fact dispense with the non-natural. Without cutting off many perfectly reasonable questions from inquiry, it cannot do so.

We can ask a second question: can science explain all observable phenomena? Or are their barriers or obstacles to such full explanation? Disagreements arise over matters such as how one would recognize a barrier, how one would look for it, and whether any barrier should be accepted as absolute. If one has decided in advance that no such barrier can possibly exist, then one would never recognize (or

acknowledge) one regardless of how plainly it appeared. On the other hand, those convinced that such barriers must exist will tend to find them. Curiously, the fact that the Intelligent Design school has zeroed in on this point, and is trying to give rigor and clarity to the question of barriers through its notions of "irreducible complexity" and the "design filter", is causing enormous alarm and consternation among the evolutionary biology community. As indicated, this question is ultimately one of reductionism.

II. Problems Arising in Connection with Naturalism

In order to understand the problems posed by naturalism, a much deeper view into those problems is necessary. As always, it is important to know what we are talking about. So can we devise a clear definition of naturalism?

A. Can naturalism be clearly defined?

Naturalism is key to understanding science and to metaphysical theories erected over it. Obviously both of these require clear, unambiguous definitions of naturalism and the natural. These discussions have to do with the characterization of scientific methodology, and on the basis of that characterization, to infer what explanations or types of explanations are scientific and what are not scientific. In effect, we are told that the natural and the supernatural form a partition of all…of all what? Of phenomena, of statements, or of reality? For now let us consider the former. We have the following diagram:

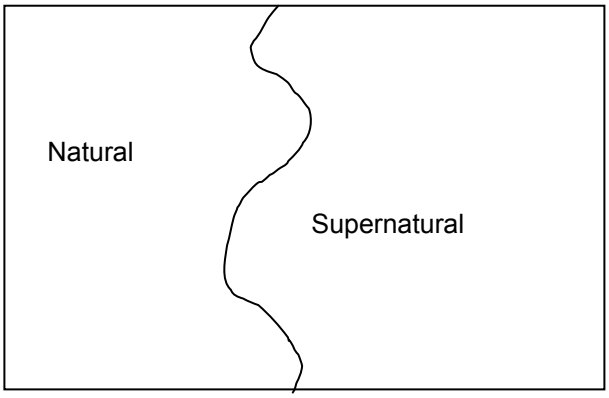

Figure 2. Division of Phenomena into Natural and Supernatural

But what is the nature of that dividing line? In some cases the distinction is clear. For example, God would be securely placed on the supernatural side. And the case of the moon's orbit around the earth is clearly on the natural side. But is there such a thing as the transcendental? If so, is it natural or supernatural? If not, why is it such a part of human thought? What about truth, justice, and beauty? From chaos and fractal theory, we have become accustomed, in recent years, to recognizing that dividing lines formerly thought to be quite sharp actually can be infinitely complex. Or they can involve gradations, as in Figure 3. And while arguments from analogy, such as this, have only limited value, they are a useful window onto an unfamiliar world.

A similar problem exists with respect to the division between "naturalistic" and "non-naturalistic" (statements, arguments, explanations, etc.). We do not know the nature of the dividing line. Is a hard and fast division possible? Problems begin with human perception, the ultimate basis for any empirical science. Are colors as perceived naturalistic? What about

sounds? There are many psychological phenomena that seem real and seem to form part of the "natural" world, such as dreams and consciousness. And there are abstract entities and essences, subjects of investigation at least since the time of Plato and his Ideas. Aristotle—more down to earth—certainly regarded essence, the tØ tˆ Çn e□nai, what makes a thing be what it is, as naturalistic.

The matter is especially interesting because virtually no one who discusses science, including Creationists, claims that we have access to anything other than sense data. Yet most have concluded that we can have knowledge of something beyond what sense data delivers, and indeed that such knowledge is necessary to understand the world. Transcendental knowledge, for example: knowledge of truth, beauty, etc., comes from our ordinary knowledge. Anyone who has stood before a great painting and been moved deeply, or who has had a similar experience when listening to great music or hearing great literature, knows that this experience of the transcendental is very real. Many other experiences of daily life have the same import: experiencing the beauty of nature, deep friendships, or even contemplating the mysteries of nature that the scientist seeks to understand. For example, many (such as Robert Jastrow) turn to religion from the study of astronomy.

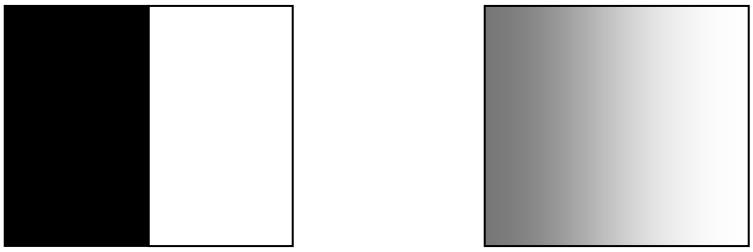

Figure 3. The two views of science and philosophical/theological knowledge. (a) hard-and-fast distinction. (b) gradual progression

Zubiri expresses the transcendental in an interesting manner:

> There are things we do not perceive directly, not because they are *ultra*, beyond the things we encounter directly, but precisely the opposite, because they are something that is in every perception and in each thing. We do not perceive them precisely because they are constitutively inscribed in the obvious; we do not perceive them…because they lack that minimum opacity necessary for human beings to encounter them. That lack of opacity is what the term *diaphanous* expresses…the diaphanous is transcendental. It is transcendental, not in the sense that is something very important, but in the sense that it transcends in one form or another those things that are obvious, without however being outside of the obvious things.[8]

This suggests that even things believed to be securely in the naturalistic camp have aspects that go beyond what science can investigate. Does that make them somehow non-naturalistic, or does it point to the need for a broader view of reality than metaphysical naturalism conceives? Those who maintain the existence of the supernatural do not claim that we have some sort of sixth "supernatural sense" that allows us to perceive the supernatural. Rather, they maintain that the supernatu-

ral can be perceived through the five senses. As St. Paul famously remarked, "For since the creation of the world His invisible attributes, His eternal power and divine nature, have been clearly seen, being understood through what has been made…"[9] Moreover, as discussed above, the concept of the transcendental, in philosophy, has historically referred to the fact that we perceive things (e.g., beauty, truth, being) that are not immediate sense perceptions.

B. Can Naturalism be Defined in a Neutral Way?

This leads to question of whether naturalism can be defined in a "neutral" way, i.e., in a way that does not make metaphysical assumptions, or at least does not entail significant metaphysical implications. The key idea behind naturalism is that of *nature*, understood as something subject to systematic inquiry by rational, empirically-based methods. Naturalism thus involves an *object of study*, and a *method* of studying it. The method of studying nature—the "scientific method"—will be discussed below. The object of study involves nature as something real, in which we are immersed, and which we can describe in precise language that is inter-subjective. The objective is to determine regularities in the phenomena of nature, which indicate that there are underlying realities, called "natural laws", which govern those phenomena. Such laws generally deal with low-level entities, from which higher-level entities are constructed, and higher-level phenomena are explained. Thus atoms and energy are used to explain chemistry and thermodynamics. Subatomic particles are used to explain atoms, etc. The low-level entities are always capable of being observed and measured by any observer with suitable equipment. *Naturalistic* therefore refers to such entities and phenomena. Typically this idea is combined with that of *reductionism*, though this is a philosophical step that is not required for the conduct of science. Thus it is inferred that all phenomena and by implication all reality can be explained by these naturalistic entities. By invoking reductionism, in effect *methodological* naturalism is turned into *metaphysical* naturalism. However, this entire paradigm makes an important assumption, namely that one can catalog those entities or phenomena that are permitted in scientific explanations. As we shall see in the next section, this is an extremely problematic philosophical assumption.

III. Components of Naturalism: The Canon of Reality and the Scientific Method

As indicated above, naturalism is based on two important ideas, the *canon of reality* and the *scientific method*. Resolution of the foregoing problems, and a clear understanding of naturalism, both require an understanding of these ideas, both of which, ultimately, have their roots in philosophy.

It may seem a bit odd, at first glance, that the naturalistic depends on both the canon of reality and the scientific method. But both are essential, because not just any theory or formula with entities from the canon is naturalistic. Consider Newton's second law, $F=ma$. This law was derived by a strictly scientific process, and then experimentally tested. We could easily write down many other equations with the same observable quantities, such as $F=ma^2$, or $F=\sin(ma)$. But they would not be naturalistic because they were not derived by a scientific process and do not correspond, even in first order, to any observable phenomena. They are simply mathematical fantasies.

A. The Canon of Reality

Science inevitably works by utilizing a *canon* (from the Greek κανον, rule), which is the set of things deemed to be acceptable as objects of science. As discussed earlier, this is often taken in general terms as "matter and energy". The implication is that the canon can be clearly and unambiguously delineated. However, upon closer inspection, the canon of science or the *canon of scientific reality* is often hazy. For example, in medicine, there is the problem

of the interaction of mind and body. What is the mind, and is it real, does it form part of the canon? Are colors naturalistic? What about other psychological phenomena, such sounds, or even dreams? While it might be relatively easy to disregard dreams, colors are more difficult. If we discount or reject colors, we are in danger of rejecting the whole basis for our perception of nature and natural phenomena.

While in many cases it may seem that the division is clear, consider the following question: Does prayer help people heal faster? This is a straightforward question about something that happens in the world, namely the speed of healing, which should therefore be amenable to empirical—scientific—investigation. But how would it be formulated? How would the scientist determine if someone is "praying"? Surely going through the empirically observable motions of saying certain word or holding one's hands in a particular way does not constitute what religious people understand by "prayer". But without a suitable operational definition of prayer, it is difficult to formulate a good experimental test of the hypothesis. Does this mean that the question cannot be investigated scientifically? No. Can the question be dismissed as meaningless because religion is hokum? No, because such a dismissal would involve an *a priori* judgment about something which, being empirical, could turn out differently than expected. What it does mean is that the division between the natural and the non-natural becomes hazy in at least some areas.

Let us consider another problem, that of defining what a species is. Clearly all of evolutionary biology hinges on this definition in some way. If a species cannot be defined in an appropriate operational manner, it becomes very problematic to speak of evolution of species. Yet this is, in fact, not so easy. Historically—prior to Darwin's time—biologists conceived of species almost in the Platonic sense, as immutable Ideas, perhaps in God's mind. Any individual organism was thus an imperfect representation of the true form of the species, unchanging and eternal. To a considerable extent, this is still the position of the Creationist school. The modern view is essentially nominalistic, defining species in terms of reproductive isolation. For nominalists, there is no problem with changing and evolving species; species have no separate, eternal reality anyway. Darwin gravitated to this position, which has become an essential part of modern evolutionary thinking:

> I look at the term 'species' as one arbitrarily given, for the sake of convenience, to a set of individuals closely resembling each other, and that it does not essentially differ from the term 'variety,' which is given to less distinct and more fluctuating forms. The term 'variety,' again, in comparison with mere individual differences, is also applied arbitrarily, for convenience's sake.[10]

Prominent members of the Neo-Darwinian school openly admit their goal of establishing a nominalistic foundation for biology and taxonomy. Mayr expresses his pleasure in "eliminating the last remnants of Platonism, by refusing to admit the *eidos* (idea, type, essence) in any guise whatsoever." [11] Eisely follows suit.[12] John Maynard Smith, another member of the school, explains its reasons for rejecting the realist approach:

> The theory of evolution holds that existing plants and animals have originated by descent with modification from one or a few simple ancestral forms. If this is true, it follows that all the characteristics by which we can classify them into species have been and are changing, and further that on many occasions in the past a single populations has given rise to two or more populations whose descendants today are sufficiently different from one another to be classified as different species….Therefore *any attempt to group all living things, past and present, into sharply defined groups, between which no intermediates exist, is foredoomed to failure*.[13] [italics added]

Because the philosophical dispute between nominalists and realists is about what is real and what is not, the injection of this dispute into science, in order to define what a species is, clearly reveals the difficulties involved in any hard-and-fast definition of the canon of reality.

In the 18th century, it was widely accepted that there is a distinction between primary and secondary qualities, and that only the former were really important with respect to nature. In the 19th and early 20th centuries, physicists thought that they had everything pegged with a deterministic billiard-ball model of reality. The idea of things that could be waves under some circumstances and particles under another was not part of their canon. Nor were things that had inherent uncertainties. But even in high-energy physics today, supposedly the hardest of the hard-core science, things are not always so clear. Nobody knows what dark matter is, let alone dark energy, how they may interact with "regular" matter, or what properties they may have. The uncertainty principle made clear that full explanation by means of physical laws, as envisioned by Laplace's Demon, was an unrealizable fantasy, thus delivering a great blow to reductionism. A bit further removed, we may ask about the reality of mathematical entities such as abstract spaces, imaginary numbers, etc. Typically we assume that the canon of scientific reality is a subset of the canon of all reality, as shown in Figure 4, though the exact nature of this relationship is a matter of some dispute. Reductionists, in particular, argue that it the two are the same.

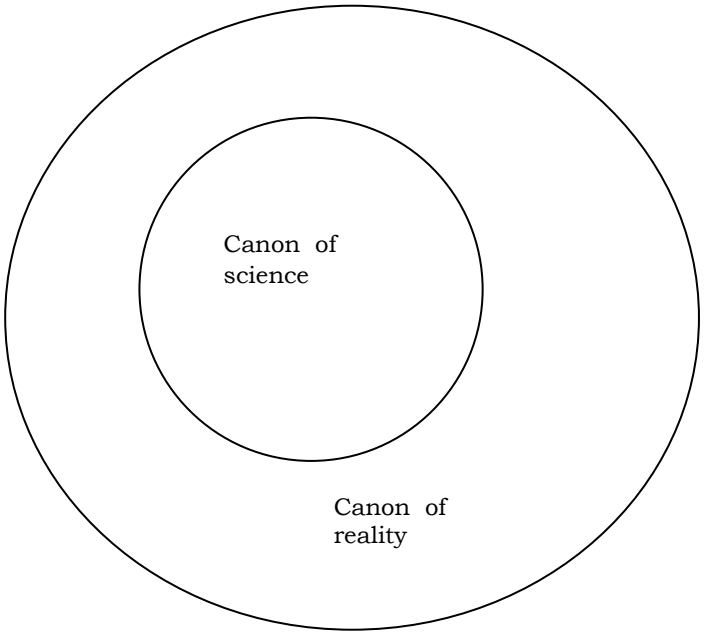

Figure 4. The canon of scientific reality and the canon of reality overall

The impact of the canon of scientific reality on methodological naturalism is fairly straightforward: we can only accept those things in the canon as viable components of scientific theories. This does not mean that other things, excluded from this canon, are not real, only that they are not allowed as components of scientific theories and explanations. Nor does this mean that the canon cannot change, as indeed it has done historically on many occasions. And it does not mean that

things in the canon cannot be subjects of knowledge in other fields as well, including literature, theology, and philosophy. For example, we can discuss the universe in all three of these contexts, as well as in the context of science.

But it is in the realm of metaphysical naturalism that the importance of the canon becomes paramount, because then the canon becomes the ultimate arbiter of what can be accepted as real in the only meaningful sense, and what must be dismissed as an illusion, an epiphenomenon, or a myth. The problem, of course, is that the whole notion of a canon is ultimately a philosophical one, and therefore outside the realm of science.

Of great importance is the fact that the canon of scientific reality, as discussed above, is not static. Moreover, as science develops, it contributes to and modifies the overall canon of reality. Exactly how this happens, and how we come to accept new realities, is a subject that has heretofore received very little attention, despite its obvious importance. Clearly for many, forcing acceptance of metaphysical naturalism has overridden the more modest but more important task of understanding the nature of the canon. There is, in addition, the problem of determining how other realities such as mathematical entities, abstract entities, spiritual entities, and psychological phenomena, for example, fit into the canon.

A review of the history of science readily discloses that science has repeatedly and profoundly changed our view of the world and of reality, and thus affected our canon of reality, as well as affecting the specific canon of scientific reality. The process is thus a feedback loop, as illustrated in Figure 5:

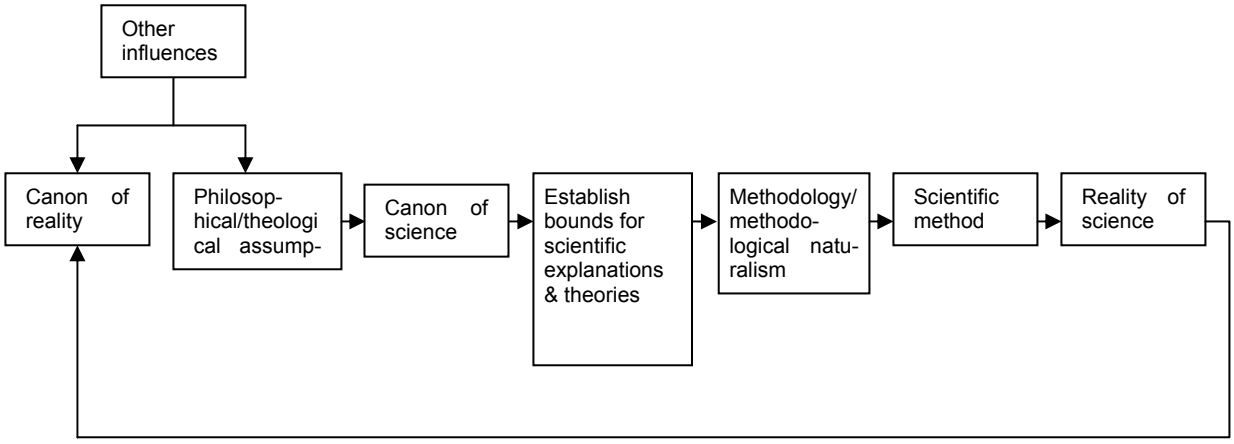

Figure 5. Feedback loop for influence of science on canon of reality and canon of scientific reality

Will this feedback loop converge? Science has at times introduced bogus entities into the canon, entities such as phlogiston (to explain combustion and heat phenomena) and the aether (supposedly the carrier of electromagnetic waves). In theory, and largely in practice, science has been able to eliminate these bogus entities; but they can come and go, as the cosmological constant has done. The canon has never been fixed, and may never be so

So the question of convergence is a difficult one, equivalent to asking the difficult philosophical question of whether we will ever know everything, or how much we can know, or something similar. As Zubiri notes,

> The limitation of knowledge is certainly real, but this limitation is something derived from the intrinsic and formal nature of rational intellection, from knowing as such, since it is inquiring intellection. Only because rational intellection is formally inquiring, only because of this must one always seek more and, finding what was sought, have it become the principle of the next search. Knowledge is limited by being knowledge. *An exhaustive knowledge of the real would not be knowledge; it would be intellection of the real without necessity of knowledge.* Knowledge is only intellection in search. Not having recognized the intrinsic and formal character of rational intellection as inquiry is what led to…subsuming all truth under the truth of affirmation.[Italics added][14]

The canon of reality allows us to search for new things and new forms of reality. It is thus a guide, but of a particular and essential sort:

> A canon is not a system of normative judgments but is, as the etymology of the word expresses precisely, a "metric"; it is not a judgment nor a system of judgments which regulate affirmative measurement. This "metric" is just what was previously known intellectively as real in its form and in its mode of reality. The thinking intellection goes off in search of the real beyond what was previously intellectively known, based upon the canon of reality already known.[15]

The relationship among canon of reality, scientific method, methodological naturalism, metaphysical naturalism, and reductionism can be viewed schematically, as in Figure 6:

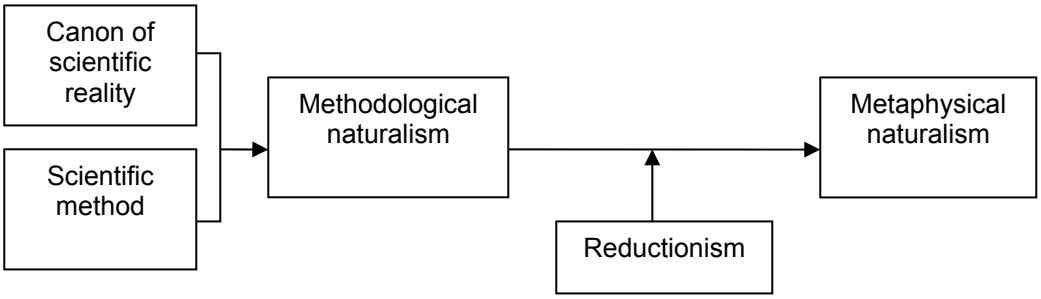

Figure 6. Relationship among canon of reality, scientific method, types of naturalism, and reductionism

Combining the scientific method with the canon of scientific reality, one achieves methodological naturalism. Metaphysical naturalism requires that the notion of reductionism be added to that of methodological naturalism.

B. Naturalism and the Scientific Method

To fully understand naturalism we must consider how science actually works—the "scientific method". Exactly what this method is, and indeed the question of whether there is a single scientific method, are topics that have been debated now for almost a century. The "scientific method" is an analogical rather than a univocal concept, further contributing to the nebulosity of "naturalism", though certain steps in it are common. For example, a physicist working on superconductivity or lasers can conduct direct experiments in a way that an astrophysicist working on stellar evolution or black holes cannot. Machines such as the Large Ha-

dron Collider can expand the range of direct experiments that we can do; but direct experimentation will always be limited by time, energy, and in some cases, chronology. Nonetheless, some aspects of how science works are clear, even across disciplines as disparate as biology and physics.

> The purpose of science is to investigate the natural order—natural phenomena—and explain what we have *already* observed as well as predict what we *will* observe and what we *won't*. A scientific *theory* is a set of hypotheses and definitions, together with certain rules of inference which, given some boundary conditions and empirical facts, can *explain* in a concise and compact manner a large number of already known natural phenomena. In addition, any theory should *predict* new natural phenomena, while at the same time *excluding* the possibility of others. Exclusion of some conceivable observations is extremely important, because it is this feature which guarantees that the theory will convey new information to us. A theory which can "explain" any conceivable observation does not explain anything at all—it is irrefutable, but at the price of imparting no real information.[16]

In general the idea is to explain a large variety of phenomena in an economical way, as the result of a small or relatively small number of natural processes acting. The action of these processes is usually expressed in terms of scientific laws.

But before we can have scientific laws, we must do observations of regularities in natural phenomena. On the basis of these regularities, the scientist can formulate explanatory hypotheses, often expressed mathematically, such as Newton's three laws. The scientist uses these hypotheses to ask questions of nature. We term these questions "experiments":

> But the questions are such that the scientist *has already formulated answers (predictions)*; he or she only wishes to know if nature will *confirm* these answers (predictions). Thus science has a crucial *experimental* component, and we often use the term "experimental science". If the predictions are confirmed experimentally, the hypothesis receives a boost and further predictions and experimental tests are performed; if not, the hypothesis is either modified or discarded, and the process is restarted.[17]

The experiments need not refer to future events; they can refer, through predictions, to past events, events too distant in space for direct manipulation, or events on too large a scale for human action:

> The key point is that investigators *are told to look somewhere that they have not looked before, for something they have not seen before*. It is this ongoing experimental verification and feedback that distinguishes science from philosophy and other types of knowledge.[18]

There are five identifiable steps in the scientific method, which may be summarized as follows:[19]

1. *Start with some knowledge of reality*. All science is based on observations which ultimately derive from apprehension, and all rational explanations are intended to tell us about reality beyond apprehension which may account for our observations.
2. *Postulate reality*. This may involve postulation of new realities such as atoms or quarks, and their characteristics stemming from their essences; or it may involve postulation of new functional relationships among things already known, such as the Universal Gas Law. There may be a combination of the two.
3. *Explore the postulated reality*. At this stage the scientist explores the new reality which has been postulated by the tools at his disposal. Typically this involves deduction or other inference of consequences about the new reality, which can be

tested. As discussed above, the test does not necessarily require experiments that will directly manipulate reality, as is usually done in physics.

4. *Verify*. At this stage the scientist seeks to determine if what has been learned through the exploration of postulated reality is in accord with our experience of reality beyond apprehension. This is done by finding things in the postulated reality which have not yet been observed in reality beyond apprehension, and then searching for them in that reality, usually by experimentation. Verification in this case takes the form of congruence.
5. *Modify the canon of reality*. Successful theories remain as beyond-reality-postulations and the reality they postulate usually enlarges our canon of reality; unsuccessful theories become essentially literary postulations; indeed, "science fiction" as a literary genre is closely related to failed scientific theories.

But with any attempt to give precise expression to a process of knowledge acquisition, there is inevitably a degree of uncertainty and vagueness, because human language and human thought can never precisely express either the full nature of the process (now or what it will be in the future) or the type of knowledge to be acquired. One need only attend any scientific conference to discover that nearly all papers start with some type of disclaimer that they are approximations, that certain facts are ignored, and so forth.

Since the postulated reality is intended as an accurate description of reality beyond apprehension, it is necessary to be on guard against a serious temptation: taking the postulated reality as a complete description of reality beyond apprehension and then rejecting any evidence which contradicts it. This state of affairs occurs periodically in science—usually when philosophical or other doctrines take precedence over purely scientific considerations—and as a result all empirical evidence is interpreted as somehow verifying the postulated reality. This occurred in the case of the geocentric theory of the universe for example. Typically this state of affairs leads to great tensions and eventually to some type of paradigm shift.

When the scientist formulates an hypothesis such as "all bodies acted on by gravity fall with the same acceleration", or "all life forms are descendants of an original life form", the hypothesis deals with at least some phenomena that are observable today. In the first case, this is obvious: we can easily drop bodies and measure their acceleration. In the second case, we can observe today's life forms, and at least the remains (fossils) of life forms that are extinct. We cannot observe the "original life form" or most of the intermediates, though they would have been observable had we been alive at the time. It is at this point that the crucial experimental requirement enters: we have to look somewhere we have not looked, for something we have not seen before. So even in the case of the common descent hypothesis, there are experimental implications. That is, the hypothesis should tell us to examine something, say DNA, that is observable today, and we should see something there that we had not observed before. Or we should look for something in the fossil record (which is observable) for some pattern that we had not observed before. One reason we may not have observed the phenomenon before is that the reality postulated by the new hypothesis was not part of our canon of reality before. This again shows how difficult it is to pin down the dividing line between the naturalistic and the non-naturalistic.

As a practical matter, the issue does not always arise in the day-to-day practice of science. For example, as these lines are written, the Large Hadron Collider at CERN is being tested operationally. The giant machine has been designed using standard physical principles, with no need to invoke anything non-natural. And despite all of the loose talk about the Higgs boson as the "God particle", no one se-

riously expects the machine to show us anything that requires a supernatural explanation, or tell us anything about God or theology, at least not directly (all reality discovered to us has extra-scientific dimensions and implications). But of course that does not mean that all aspects of matter will be explained by any "theory of everything". In fact, to even pose this question reveals the non-scientific character of the discussion.

In many cases such as those mentioned earlier, such as the problem of prayer and healing, not merely the canon of reality but the nature of the scientific method itself is less than clear. Obviously, language cannot explicitly formulate the scientific method, because the method is always changing and evolving and it is simply not capable of being put into a strict algorithmic form. This haziness surrounding the scientific method accrues to naturalism as well.

Moreover the boundary between science and philosophy can be difficult to discern. As two engineering professors from Oxford have noted,

> The advent of quantum mechanics brought problems to the physicist which previously belonged to the sacred domain of philosophy. The engineer can still afford to ignore the philosophical implications but by a narrow margin only.[20]

A perusal of the literature dealing with interpretation of quantum mechanics, dark matter, black holes, the big bang, string theory, or many other areas of current interest in physics will quickly reveal just how blurry the boundary can be.

IV. Summary and Conclusion

Naturalism is a much more complicated and obscure doctrine than is commonly believed. A careful analysis of it reveals at least five aspects, which were discussed in this paper:

1. The distinction between the naturalistic and the non-naturalistic: is it black-and-white, or a gradation? As we saw, this question depends on the canon of reality and the scientific method. Since neither of these can be defined or delineated precisely, any distinction between naturalistic and non-naturalistic will be hazy, and only exhibit characteristics of a hard-and-fast distinction in limited areas.
2. Naturalism with respect to the canon: what is real for science (the scientific canon), and what is real in the fullest sense?
3. Naturalism and the scientific method: the analogical nature of the scientific method, its evolving form, and the inability to give explicit algorithmic formulation to it all mean that naturalism itself is characterized by a certain haziness, because it is the scientific method that determines, in large measure, the acceptable form of scientific statements, laws, and theories.
4. Naturalism and the Implications of science: It is clear that science reveals to us aspects of reality of which we would otherwise be unaware, and we accept these things now as part of the canon of reality in the fullest sense. Examples are genes, dark matter, dark energy, the weak and strong nuclear forces, tectonic plates, black holes, and quasars, just to name a few. Science thus adds naturalistic entities to our canon; can it also take them away? Is our non-scientific intuition of any value? Statements about reality are metaphysical; how does this philosophical position square with the fact that science is now the main thing that tells us about new realities?
5. Reality aspects of objects investigated/discovered by science: Independently of science, things have aspects of reality such as truth, beauty (transcendentals), and reality itself has characteristics, such as its

field nature. To what extent are these "naturalistic"?

Together these five aspects of naturalism reveal that it cannot be defined in a hard-and-fast manner because of problems with the canon of scientific reality, the scientific method, and the relationship between these two. The belief that science could be defined by naturalism assumed that the canon of scientific reality could be fixed, and the scientific method could be clearly and unambiguously defined. The reality is that both involve some gray areas, and therefore so does naturalism. In part, continuing developments in science can change canon of reality and affect philosophical theories. The canon is driven by philosophical assumptions. The failure of reductionism means that elimination of non-naturalistic notions (reality) cannot be accomplished. Methodological naturalism cannot be used to define what science is, because it relies on something antecedent, namely the canon of scientific reality that one presumes, the type of scientific method that one deems acceptable.

Secondly, real things have aspects that are not capturable or even definable by science. These include transcendentals such as truth, beauty, etc. This does not really affect methodological naturalism, but is fatal for metaphysical naturalism.

So what can we actually do? The best that we can do, and what scientists do in practice, is to choose a particular canon (which may be different for the psychologist than for the physicist), agree on the details of what is an acceptable scientific method, and then see how far they can get. It is fairly straightforward to include some things, such as elementary particles (for the physicist), or atoms (for the chemist or biologist), and to exclude some things (such as God) from the canon. Within limited areas of human experience, the results may be quite satisfactory. For example, Newtonian mechanics works quite well in many applications, and did so long before the advent of Relativity or quantum mechanics, and it continues to be extremely useful. The results of this process may lead to revisions in the canon of scientific reality and hence in that of the canon of reality in general. But it cannot displace or replace the canon of reality in general, nor can it guarantee that we have found the final, definitive canon.

Notes

[1] Paper presented at Metanexus Institute conference "Cosmos, Nature, and Culture: A Transdisciplinary Conference", July 18-21, Phoenix, Arizona.

[2] Niles Eldridge, *The Monkey Business: A Scientist Looks at Creationism*, New York: Washington Square Press, 1982, p. 82.

[3] Eldridge, *The Monkey Business*, *op. cit.*, p. 87.

[4] Eugenie Scott, " 'Science and Religion,' 'Christian Scholarship,' and 'Theistic Science': Some Comparisons," *Reports of the National Center for Science Education*, 1998, volume 18(2), pp. 30-32, available on web at www.ncseweb.org/resources/articles/6149_science_and_religion_chris_3_1_1998.asp.

[5] Michael Ruse, "Witness Testimony Sheet McLean v. Arkansas," in *But Is It Science? The Philosophical Question in the Creation/Evolution Controversy*. New York: Prometheus Books, 1996, p. 296.

[6] Richard Lewontin, Review of Carl Sagan's *The Demon Haunted World: Science as a Candle in the Dark*, in *The New York Review of Books*, 9 January 1997, pp. 28, 31.

[7] Steven Weinberg, *Dreams of a Final Theory: The Search for the Fundamental Laws of Nature*. New York: Pantheon Books, 1992, p. 247.

[8] Xavier Zubiri, *Los problemas fundamentales de la metafísica occidental*, Madrid: Alianza Editorial/Fundación Xavier Zubiri, 1994, p. 19. Translation by Joaquin Redondo and Thomas Fowler.

[9] Romans 1:20, *New American Standard Bible* translation.

[10] Darwin, Charles, *Origin of Species*, chapter 2, "Doubtful Species", New York: Mentor, 1958, p. 68.

[11] Mayr, Ernst, Introduction to the facsimile edition of *Origin of Species*, Cambridge: Harvard University Press, 1966, p. xi.

[12] Eisely, Loren, *The Firmament of Time*, Athenium: 1960.

[13] Smith, John Maynard, *The Theory of Evolution*, New York: Penguin, 1958, p. 152.

[14] Zubiri, *Sentient Intelligence,* translation by Thomas Fowler, Washington, DC: Xavier Zubiri Foundation of North America, 1999, p. 336; Spanish original, *Inteligencia y razon*, Madrid: Alianza Editorial/Fundación Xavier Zubiri, 1983, p. 261-262.

[15] Zubiri, *Sentient Intelligence*, op. cit., p. 261; *Inteligencia y razon*, p. 57.

[16] Fowler, Thomas, and Kuebler, Daniel, *The Evolution Controversy: A Survey of Competing Theories*, Grand Rapids: Baker Academic, 2007, p. 126.

[17] *Ibid.*, p. 127.

[18] *Ibid.*, p. 128.

[19] Fowler, Thomas, "Zubiri's Reality by Postulation and its Implication for the Relationship Between Science and Religion", paper presented at Metanexus conference "Continuity + Change: Perspectives on Science and Religion", June 3-7, 2006, in Philadelphia, PA, USA.

[20] L. Solymar and D. Walsh, *Lectures on the Electrical Properties of Materials,* Oxford: Clarendon Press, 1970, p. 57.