WHY METHODOLOGICAL NATURALISM?

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> ... any confusion between the ideas *suggested* by science and science itself must be carefully avoided.
>
> Jacques Monod, *Chance*

1. Introduction

In the ongoing controversy between evolutionary biology and creationism, those on the science side usually maintain that evolutionary theory obeys the following principle:

> *Methodological Naturalism*: Scientific theories should be neutral on the question of whether a supernatural God exists.

Defenders of evolutionary biology often make a second point — that this methodological principle needs to be distinguished from a thesis about what there is:

> *Metaphysical Naturalism*: No supernatural God exists.

The thought here is that evolutionary biology has no commitment to this second form of naturalism; like scientific theories generally, evolutionary theory is committed to *ignoring* the supernatural, not to *denying* its existence.

Four clarifications are needed. The first concerns the term "supernatural." Think of nature as the totality of entities, events, and processes that have spatio-temporal location; supernatural entities, as I'll use the term, do not.[1] The second point is that methodological naturalism says nothing about the sources of inspiration that scientists may avail themselves of in developing their theories; the doctrine concerns the theories produced, not the psychological processes leading to that product. My third comment is that I have formulated these two naturalistic principles so that they are

[1] I'll avoid saying that supernatural entities are "outside" of nature, as this suggests that nature is a box and that supernatural things have a spatial location — they are outside or above the box. Nor is it part of what I mean by "supernatural" that supernatural beings are better than natural ones.

specifically about God and do not pertain to the category of supernatural entities more generally; this wider philosophical context is something to which I'll return.

My fourth clarification brings me to the quotation from Monod with which I began. Many people take evolutionary theory to suggest that there is no God.

This thought has motivated *some* atheists and *all* creationists. But here we must be careful. There is a difference between the ideas that a theory may bring to mind and what the theory *actually says*. When I hear the *Marseillaise*, I sometimes think of Humphrey Bogart, but the lyrics of the French national anthem do not entail the existence of Bogart. Methodological naturalism does not prohibit scientists from formulating theories that inspire thoughts about God, either *pro* or *con*. Methodological naturalism concerns a logical issue, not a psychological one.

What do creationists say about the relation of evolutionary biology to these two naturalisms? Sometimes they deny that evolutionary theory obeys methodological naturalism; their thought is that evolutionary theory is a materialist philosophy that embraces metaphysical naturalism and therefore violates the neutrality required by the methodological principle. However, at other times creationists agree that contemporary evolutionary biology obeys methodological naturalism, though they add that this is a defect, not as a laudable achievement. Creationists think that methodological naturalism is a shackle from which science needs to be emancipated. Refusing to consider questions about the supernatural, they maintain, is the act of an ostrich sticking his head in the sand.

My main goal in this paper is to explore the question of why science should embrace methodological naturalism. After criticizing some answers that have been suggested, I'll provide an answer that is less ambitious; I hope it is more defensible. But before I consider how methodological naturalism might be justified, I want to say something about the kind of theistic neutrality that evolutionary theory has achieved. It is obvious that the theory is not neutral with respect to *all* claims about God. For example, the theory rules out the thesis that God created life on earth about 10,000 years ago. It also is clear that the theory is inconsistent with Creationism, which is the first of the three theistic positions depicted in *Figure 1*. Creationism maintains that the complex adaptive features that we observe organisms to have could not have been produced by the evolutionary process, but were the result of God's directly intervening in nature.[2] The second position represented in *Figure 1*,

[2] Sometimes creationists describe what they take evolutionary theory to be unable to explain by distinguishing micro- from macro-evolution. For the purposes of separating the three theistic positions depicted in *Figure1*, this point does not matter.

Deism, maintains that God starts the evolutionary process and then never intervenes in what happens subsequently. Deism makes it clear that evolutionary biology does not contradict the proposition that God exists. In addition to Creationism and Deism, there is a third position to consider; it says that evolutionary theory can explain the features that organisms have, but that it is explanatorily incomplete, in that God has been at work as well. This may sound like Creationism, but it is not.

The arrows in *Figure 1* represent causal relationships. I do not assume that causality requires determinism. Smoking cigarettes causes lung cancer, but that doesn't mean that you will get lung cancer if you smoke. It doesn't even mean that smoking is part of a larger set of causal conditions that jointly suffice for lung cancer. Perhaps the universe is irreducibly chancy. As a rough approximation, we can think of causes as events that increase the probabilities of their effects. Causality can be deterministic (with complete sets of causes pushing the probabilities of their effects to a value of 1), but it need not be.

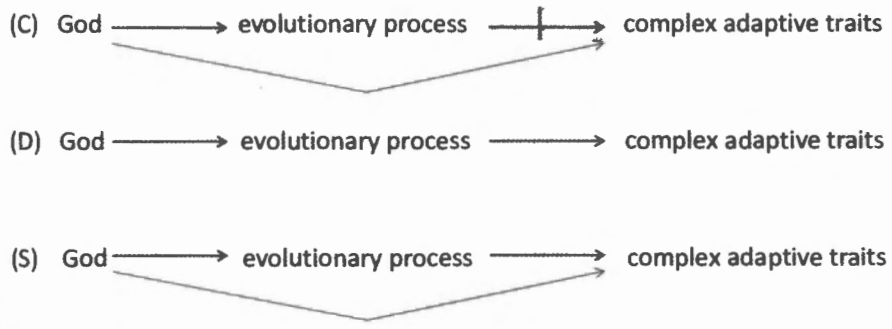

Figure 1: Three theistic positions. Creationism (C) holds that the evolutionary process is incapable of producing the complex adaptive traits of organisms that we observe, and that these are the result of God's direct intervention. Deism (D) holds that God starts the evolutionary process and never intervenes. And (S) holds that God sometimes intervenes in nature, supplementing the processes described in evolutionary theory.

Deism (as I'll understand that position) says that God builds organisms exclusively by way of the evolutionary process. This position is naturally represented in terms of a probabilistic equality:

> Pr(traits of organisms | evolutionary process & God exists) = Pr(traits of organisms | evolutionary process & God does not exist).

Once the evolutionary process is under way, what happens subsequently is unaffected by whether God exists; the process *screens off* God's existence from the

traits that organisms possess. Creationism and the supplemental position (S) are both interventionist; they agree that this screening-off thesis is false.

I'll assume in what follows that the God we are discussing, if he exists, is a supernatural being. Not all conceptions of God are like this; the ancient Greeks took their gods to inhabit Mount Olympus and Spinoza thought that God is identical with nature itself. It is curious that methodological naturalism does not prohibit bringing such deities into science. Although there may be other reasons to keep them out, that is not my subject here.

Two of the three positions represented in Figure 1 involve divine intervention in the world of space and time after the universe passes beyond its first moment (if it has a first moment). But what does "divine intervention" mean? In theology, it is often understood to mean God's violating the laws of nature.[3] I do not use the term in this way. What I want to consider under the heading of (S) is the view that God *supplements* what happens in the evolutionary process without violating any laws. An intervention, as I'll understand the term, is a cause; it can trigger an event or sustain a process. Physicians do both when they intervene in the lives of their patients. Physician intervention does not entail any breakage in the laws of nature; neither does God's.[4]

2. Why evolutionary theory does not rule out an intervening God

It is not inconsistent to claim that there is more going on in the evolutionary process than is dreamt of in evolutionary biology. This is the thesis that there are "hidden variables" — causal influences on evolutionary outcomes that are not recognized in our science. If evolutionary theory were causally complete, there would be no room for this idea. However, we have no assurance that the theory covers all the facts that are causally relevant to what happens in evolution. Please note that I am not saying that there now is *evidence* that such hidden variables exist; my claim is only that they are not ruled out by current theory.

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[3] For example, Russell's (2008) NIODA (noninterventionist objective divine action) uses the term in this way. My proposition (S) and his NIODA have much in common, despite this difference in terminology.

[4] Here I find myself in disagreement with Pennock's (1999, 195) statement that "to say that some power is supernatural is, by definition, to say that it can violate natural laws." The ability to violate natural laws might be a defining property of an *omnipotent* deity, but it isn't part of the definition of a supernatural power.

The fact that evolutionary theory does not preclude the existence of hidden variables is a simple consequence of the fact that the theory is probabilistic. To see why, let's begin with a simple analogy — the tossing of a coin. Suppose you toss a coin repeatedly and obtain evidence that justifies the following conclusion:

(1) Pr(the coin lands heads at t_2 | the coin is tossed at t_1) = 0.5.

Someone who believes that determinism is true can accept proposition (1), but will maintain that there is more involved in the process of tossing the coin than is described in this probability statement. The determinist will maintain that:

(2) Pr(the coin lands heads at t_2 | a complete description of the initial conditions at t_1) = 0 or 1.

Although propositions (1) and (2) may seem to disagree about what the coin's probability of landing heads is, in fact they do not. Both describe the coin's probability of landing heads, but they relate that event to different propositions that describe what came before. Since statements (1) and (2) conditionalize on different propositions, both can be true. It makes no sense to ask what an event's true probability is. This is like asking what the true distance to Madison is. There is no such thing. There is the distance from Chicago to Madison and the distance from New York to Madison. Distance is inherently relational. Similarly for probabilities.

To further illustrate this point, consider the Newtonian model of coin tossing that Diaconis (1998) describes. The initial conditions for a toss determine whether the coin lands heads or tails. The reason a sequence of tosses exhibits a mixture of heads and tails is that the initial conditions vary from toss to toss. To simplify matters, we assume that there is no air resistance, that the tossed coin spins around a line through its plane, and that the coin lands without bouncing (perhaps in sand). The relevant initial conditions are then fixed by specifying the values of V (the upward velocity of the tossed coin) and ω (the angular velocity, specified in revolutions per second). If V is very low, the coin doesn't go up much when it leaves the tosser's hand; if ω is very low, the coin, as Diaconis says, "rises like a pizza without turning over." Depending on the values of V and ω, the coin will turn over 0, 1, 2, 3, ... times before it lands. Suppose the coin we are considering starts each tossing session by being heads up in the tosser's hand. Then, if the coin turns over 0 or an even number of times, it lands heads; if it turns over an odd number of times, it lands tails. These different possibilities correspond to the regions of parameter space shown in *Figure 2*. Starting at the origin and moving Northeast, the different stripes correspond to 0 turns, 1 turn, 2 turns, etc.

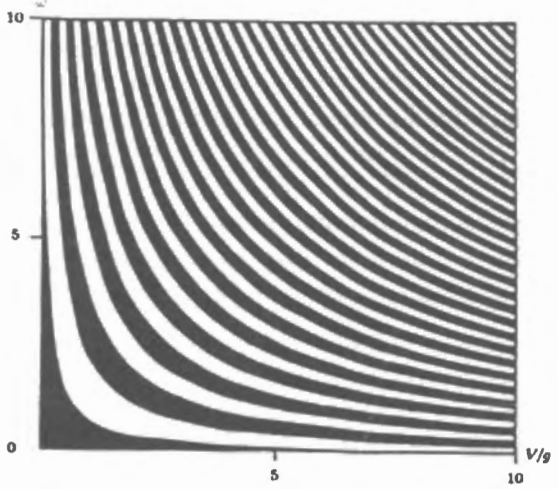

Figure 2: Coins in black regions of parameter space land heads; coins in white regions land tails (from Diaconis 1998).

In this Newtonian model, each outcome of tossing the coin is a deterministic consequence of the initial conditions, as proposition (2) asserts. However, this does not mean that proposition (1) is mistaken in its claim that the coin has a probability of landing heads of 0.5, given just the fact that it is tossed. A probabilistic model of coin tossing is consistent with the thesis that the system is deterministic. If determinism is true, there are hidden variables, not represented in the probability model (1).

Let's consider the parallel situation with respect to the claim that biologists are making when they say that mutations are "undirected" or "unguided." By this they simply mean that mutations do not occur because they would be useful to the organism. Mutations do have their causes — for example, radiation — but that is a different matter. Biologists perform experiments to test the hypothesis that mutations are undirected. Let's consider a very simple experiment that brings out some of the important features that more complex and sophisticated experiments have. Consider a species of blue organisms. Suppose these organisms would benefit from protective coloration if they were placed in a green or a red environment; being green is better than being red if the environment is green, but the reverse is true if the environment is red. Our experiment is to place some of these blue organisms in a red environment and some in a green environment and then record the frequencies with which red and green mutations occur, as shown in *Figure 3*.

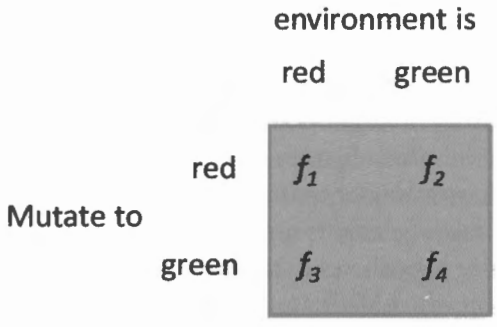

Figure 3: The frequencies with which blue organisms mutate to red or to green in different environments.

Suppose the observed frequencies are nearly identical. The conclusion a scientist will draw is that mutation probabilities are not influenced by what would be good for the organism. This should be understood for what it is — a good hypothesis whose justification comes from the frequencies of events in a sample. My point here is the same as the one about coin tosses. The hypothesis that the different mutations have the same probabilities in different environments does not rule out the possibility that there are hidden variables; perhaps each mutation that occurs is the result of its own suite of deterministic causes. If the data do not rule out hidden variables, they also do not rule out *supernatural* hidden variables.[5]

Our view of whether mutations are guided by unseen forces should be shaped by the same considerations that govern our view of whether coin tosses are influenced by unseen forces. Experts on coin tossing will tell you that coins do not land heads because this would be good for gamblers. Geneticists will tell you that mutations do not occur because they would be good for the organisms that have them. We should accept what the experts are saying, but should realize that their task is the interpretation of frequency data.

In the simple experiment that I described in which we track the mutations that blue organisms experience, the competing hypotheses describe the probabilities of

[5] Darwin's premier North American advocate, Asa Gray, wanted to supplement Darwin's theory with the claim that mutations are directed by a deity. Gray (1888) advised Darwin "to assume, in the philosophy of his hypothesis, that variation has been led along certain beneficial lines." I like the fact that Gray suggested that this addition be placed in the *philosophy* of the hypothesis, not in the *hypothesis* itself. In any event, Darwin declined to make the suggested addition.

different mutations in different environments. One hypothesis says that the probability of a red mutation in a red environment is greater than the probability of a red mutation in a green environment. Another says that these probabilities have the same value. Notice that these models say nothing about whether there have ever been mutations in the whole history of life that God made sure would happen. Scientists do not have a way of testing this theistic assertion. However, that does not show that it is false. Scientists sometimes use the derisive comment "not even false" to characterize hypotheses that cannot be tested. The derision can be separated from a point on which theists and atheists should agree: there is a difference between hypotheses that the evidence tells us are false and hypotheses that our data do not permit us to test.

The thesis that mutations are undirected is sometimes presented as a rock-bottom "philosophical" commitment of evolutionary biology, akin to materialism and just as central to the scientific worldview. This is a mistake. True, the thesis *is* central to biology, but it has nothing to do with materialism or theism. It is like the thesis that an organism can't synthesize vitamin *D* from sunlight or can't regenerate lost limbs. It is an empirical question whether mutation probabilities have the shape they do because of what would be good for the organism. The fact that many organisms do not experience guided mutations does not rule out the possibility that some do, in some environments. If it turns out that some organisms have the capacity to favorably adjust their mutation probabilities in the light of environmental change, then evolutionary biology will have the task of explaining why this is so. Mutation rates vary from species to species, across environments for a given species, and they have different values for different parts of an organism's genome. It is a good scientific question why this is so.

The fact that mutations are undirected should not be a problem for theists. Maybe God arranged for mutations to be undirected. And if some mutations in some organisms in some environments turn out to be directed in the sense I have described, that is no threat to atheism. Atheism has no more of a stake in mutations being undirected than it has in organisms being unable to synthesize vitamin *D* from sunlight.

Theists can of course be deists, holding that God starts the universe in motion and then forever after declines to intervene. But there is no contradiction in their embracing a more active God whose interventions into nature fly under the radar of evolutionary biology.[6]

[6] The probabilistic character of evolutionary theory's modeling of mutations is one reason that the theory does not rule out hidden variables, but the theory is probabilistic in another way, and this provides a second context in which hidden variables are not precluded. Here I

Divine intervention isn't part of science, but the theory of evolution does not entail that none occur.[7]

3. Should science talk only about what exists in nature?

What reasons have been offered for accepting methodological naturalism? Sometimes the claim is advanced that science, by definition, eschews discussion of the supernatural. If the point is put by saying that *natural* science says nothing about the *super*natural, the claim may sound like a tautology. But this definitional ploy accomplishes nothing. Even if "science" is defined as an activity for which methodological naturalism is true, the question remains of why time and energy and money should be devoted to doing science rather than to doing *shmience.*[8] Shmience is just like science, except that it doesn't definitionally require a commitment to methodological naturalism. As mentioned earlier, intelligent design theorists want shmience to replace science as a project to which society devotes itself. A substantive reason is needed for thinking that methodological naturalism provides good advice for inquiry. The victory that the definitional argument achieves is empty.

It is interesting to note, in this connection, that science does not, as a matter of fact, avoid postulating supernatural entities. Here I am not talking about what science says concerning the existence of God. Rather, I have in mind a different sort of supernatural entity — numbers. Evolutionary theory entails that numbers exist, and numbers are supernatural entities. Or, at least, that's the view of numbers endorsed by a certain philosophy of mathematics. Mathematical Platonism says that numbers and other mathematical objects do not have spatio-temporal location. Mathematical Platonism is not universally accepted among philosophers. However, it does have a lot to be said for it, and many philosophers think it is correct.

Here is a brief sketch of why Platonism looks plausible. Consider the claim that there are infinitely many prime numbers. This is a true statement, as any number theorist will tell you. But what are these things called numbers? What must they

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mean the fact that biological populations are finite and so natural selection is represented as a probabilistic cause.

[7] Although evolutionary theory does not rule out hidden variables, there are results in quantum mechanics that rule out certain types of hidden variables. Theists may want to consider whether they should take issue with physics about this; they have no similar bone to pick with evolutionary biology.

[8] My "schmience" is what Plantinga (1997) calls "sience"; the argument I give against the definitional ploy is his.

be like to make the statement true? First, it is important not to confuse numbers and numerals; numerals are names for numbers. The statement about primes isn't about names; it's about the things those names name. The statement would still be true if there were no language users, and hence no names for the numbers. Indeed, the statement would still be true if there were no matter in the universe. This is what leads Platonists to claim that numbers are supernatural entities.

This may explain why many philosophers think that Platonism is a plausible account of pure mathematics, but what has this to do with evolutionary theory? The answer is that many statements in mathematized evolutionary theory entail that numbers exist. Scientists hardly notice that their models have this implication, but such models are everywhere. Consider, for example, the claim that the rates of molecular evolution in two lineages are different. The Platonistic commitments of this statement become visible when it is stated a bit more formally:

> There exists a number $d \neq 0$, such that $R_1 - R_2 = d$, where R_1 is the rate of evolution in the first lineage and R_2 is the rate in the second.

Or consider the claim that the fitness of a certain trait (T) in a population is frequency dependent and is a linear function of its frequency. In other words:

> There exist numbers $m \neq 0$ and b such that the fitness of trait $T = mx + b$, where x is the frequency of the trait.

These claims are subject to empirical test, and it may turn out that the evidence leads us to reject them both. Perhaps there is a molecular clock in the two lineages; perhaps trait T's fitness is frequency *in*dependent. The important point is that scientists do not recoil from these two models because they entail that numbers exist. And if these two models are rejected, there are other models, with other Platonistic commitments, that evolutionary biologists embrace.

I mentioned before that the usual picture of the relationship of methodological naturalism and metaphysical naturalism is that the former does not entail the latter. Now let's ask the converse question: does the metaphysical thesis entail the methodological thesis? There is a simple argument for saying *yes*: if there are no supernatural entities, a true scientific theory cannot claim that such things exist. If the goal of science is to find true theories, the entailment relation is established. The problem with this argument is that science needs mathematics, whether or not Platonistic entities exist. If numbers do not exist, then mathematics is a useful fiction; indeed, it is an ***indispensible*** fiction. Scientists shouldn't worry about whether numbers exist; they should just help themselves to the as-

sumption that they do. Whether numbers exist is something for philosophers to puzzle over.[9]

4. Are claims about the supernatural always untestable?

Another way to defend methodological naturalism is to claim that statements about the supernatural are untestable. This is an old saw, and several philosophers (e.g., Quinn 1984, Laudan 1988) have cited counterexamples. I have already mentioned the following statement:

> A supernatural deity created life on earth 10,000 years ago.

Scientists have abundant evidence for life's being much older; if so, this statement about the supernatural is testable. The same point pertains to many statements that are about numbers:

> The number of apples in the basket is prime.

Both of these example statements are about supernatural entities, but they are not *solely* about the supernatural. The former is about life on earth *and* God; the second is about apples *and* numbers. Both of these "mixed" statements are testable.

Pennock (2009, 550–551), elaborating on ideas he developed earlier (Pennock 1999), disagrees:

> ... both Laudan and Quinn cite the young-earth creationist view that God created the earth 6,000 to 10,000 years ago as a hypothesis that is testable and found to be false. But this and other examples that are offered to show the possibility of tests of the supernatural invariably build in naturalistic assumptions that creationists do not share. Confronted with the empirical evidence for an ancient earth, creation scientists dismiss the relevance of any such ob-

[9] I defined an entity's being supernatural to mean that it lacks spatio-temporal location; from this it follows that numbers are supernatural entities, at least according to Platonism. But what if we adopt a different definition of "supernatural?" Draper (2004), for example, says that a supernatural entity is one that can affect the natural world without being part of it. If numbers aren't causes, this entails that numbers aren't supernatural. I guess it follows that they aren't natural, either, if being natural requires spatio-temporal location. According to Draper's definition, numbers would be neither natural nor supernatural. In any event, the question I am addressing does not depend on whether you use Draper's definition of "supernatural" or mine. Why is methodological naturalism right to council silence with respect to supernatural deities if science is entitled to construct theories that entail the existence of mathematical objects?

> servations on the ground that God simply made the earth *appear* to be old (or "mature"). Some think of this as a test of faith so that one learns to accept the authority of the Bible over that of one's (mere) senses. The point here is that we cannot overlook or ignore, as Laudan and company regularly do, the fact that creationists have a fundamentally different notion from science of what constitutes proper evidential grounds for warranted belief. The young-earth view is certainly disconfirmed if we are considering matters under MN [methodological naturalism], but if one takes the supernatural aspect of the claim seriously, then one loses any ground upon which to test the claim.

Pennock is describing an exasperating style of argument that creationists deploy. Let us see how it applies to a simpler example. Consider the statement:

> (Purple-ID) A supernatural deity caused everything in the world to be purple.

This statement is about the supernatural and it makes an observational prediction. Of course, a defender of Purple-ID might reply that things only *seem* to have colors other than purple. Friends of Purple-ID can do for their theory what friends of young-earth creationism have done for theirs. However, this is a fact about *people*, not about *propositions*. Notice the shift from propositions to people in the passage I quoted from Pennock. He begins by discussing a *proposition* (that God created the earth 6,000 to 10,000 years ago) and then shifts to a fact about how creationists defend this proposition, pointing out that "*creationists* have a fundamentally different notion from science of what constitutes proper evidential grounds for warranted belief [emphasis mine]." It is true that creationists have been unscientific, but this is a fact about them; nothing follows about the character of the theory they wish to defend. Consider a dogmatic Darwinian or a dogmatic Newtonian who argues unscientifically; this fact about them does not show that their pet theories are unscientific.

Pennock (2009, 552) thinks that the words that come out of the mouths of creationists have a radically different meaning from the same words that come out of the mouths of noncreationists. He thinks that when scientists consider "the earth is 10,000 years old" or "everything is purple," they assign the relevant terms a "naturalistic meaning," but when young-earth creationists or defenders of purple-ID utter these sentences, the sentence has a "supernaturalistic meaning." This claim of Pennock's is a claim in the philosophy of language, one that I find implausible. Creationists and anti-creationists disagree about a great deal, but that doesn't show that they assign different meanings to statements like "everything is purple" and "the earth is 10,000 years old." It is true but irrelevant that young-earth

creationists and friends of Purple-ID might adopt assumptions that make it impossible to test their theory. Being dogmatic about your pet theory does not entail that the theory you are being dogmatic about takes on a meaning that differs from the meaning the theory has when contemplated by your less dogmatic associates.

So I stand by my claim that there are mixed statements that are testable; mixed statements, recall, are ones that are about both supernatural entities and things that have spatio-temporal location. But what about statements that are *purely* about the supernatural? Consider another example that Pennock (1999, 196) discusses, namely Philip Johnson's (1990) claim that "God creates for some purpose". Does this statement have implications about what occurs in nature? Perhaps not. Pennock asserts that Johnson's claim is untestable, and maybe he is right.[10] However, it does not follow that *all* statements about the supernatural are untestable.

This suggests the following thesis: even if some of the mixed statements that creationists make are testable, their core propositions are not, and this is what makes their theory untestable. One problem with this thesis is that it is hard to tell what the core propositions are. Is "God exists" the only core proposition in young-earth creationism, or is "God created the earth between 6,000 and 10,000 years ago" also part of the core? The other problem is that even if some of the core propositions in a theory are untestable, it does not follow that the theory as a whole is untestable.[11]

Let us apply this question about creationism to science itself. Is *every* statement in a scientific theory testable? Mathematized theories in biology and in other sciences entail that numbers exist. Is the existence of numbers empirically testable?

There is an irony here. The idea that scientific statements must be testable is familiar to us in part because of the large influence that Popper's (1959) views about falsifiability have had. Popper thought that testability, understood in terms of his idea of falsifiability, was the solution to the demarcation problem, which is the problem of separating scientific statements from nonscientific statements. Philoso-

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[10] The account of testability that I develop in chapter 2 of Sober (2008) takes account of an idea that philosophers call Duhem's thesis, which says that scientific theories rarely make predictions on their own, but need to be supplemented by auxiliary propositions to do so. Perhaps "God exists" does not, all by itself, make predictions, but that is not enough to show that it can't make predictions when suitably supplemented.

[11] Consider the following two adjacent claims from Pennock (1999, 195): "... supernatural hypotheses remain immune from disconfirmation" and "creation-science does include supernatural views at its core that are not testable." The latter does not entail the former.

phers have recognized for a long time that falsifiability is a flawed account of testability (Sober 2007; 2008), but that is not the irony I have in mind. Rather, the irony is that some of Popper's contemporaries, the logical positivists, also thought that testability is a concept of central importance to science, but they denied that *every* statement in a scientific theory must be testable. Carnap (1950) and Reichenbach (1938), among other positivists, held that scientific theories often contain *conventional* elements. These are statements that are in a theory because they are useful, not because we can offer evidence that they are true. Carnap held that statements like "physical objects exist" and "numbers exist" are included in scientific theories for this reason. Physicists do not run tests to see whether physical objects exist; rather, they *assume* that there are physical objects, and then test statements like "electrons exist." And the mathematician's belief that numbers exist is not based on a mathematical proof that they do; rather, mathematicians *assume* that numbers exist, and then construct proofs of statements like "there are infinitely many primes." Contemporary discussion of methodological naturalism in connection with the debate between evolutionary biology and creationism owes a lot to Popper; the positivist heritage has largely been forgotten. This is too bad, because the idea that science uses framework assumptions that are untestable has a lot to be said for it.[12]

The positivists were not the only ones who saw that a whole theory can be testable even if some of its parts are not. This difference between whole and part is something that Popper also saw; he did so by exploring the logic of his concept of falsifiability. Popper (1959, 249) notes that a theory can be falsifiable even though some of its consequences are not. Although there is nothing paradoxical about this logical fact about falsifiability,[13] it does pose a problem for Popper's criterion of demarcation. It is hard to see how a theory can be scientific if some of its parts are not. Inspired by Popper, you may be tempted to criticize a theory by focusing on an element in the theory, declaring that element unfalsifiable, and then concluding that the whole theory is unfalsifiable. Unfortunately for those who seek

[12] Popper (1959) regarded methodological rules, like the requirement of falsifiability, as conventions. But given his methodology, a genuinely scientific statement must be falsifiable.

[13] It is standard in philosophy of science to think of theories as "closed under logical implication." This means that if a theory *T* has *C* as one of its logical consequences, then *C* is "part" of *T*. In classical logic, every theory entails a tautology. However, tautologies are not falsifiable. And even with regard to *T*'s nontautologous consequences, some of these can fail to be falsifiable even if T is falsifiable.

such silver bullets, this is not an analysis that can withstand logical scrutiny.

It is easy to miss the fact that an empirically well-confirmed scientific theory may contain assumptions that are not empirically confirmed at all. This is because there is something intuitively attractive about the following principle:

> *The Special Consequence Condition of Confirmation*: If observation *O* confirms theory *T*, and theory *T* entails that *C* is true, then *O* confirms *C*.

Confirmation does not mean that the observation *proves* that the theory is true; observational evidence hardly ever has such power in science. Rather, think of confirmation as the process of making the theory more plausible than it was before.

The Special Consequence Condition, so named by Hempel (1965, 31), may seem right, but it is not. Here's a simple example that illustrates why. You are playing poker and would dearly like to know whether the card you are about to be dealt will be the Jack of Hearts. The dealer is a bit careless and so you catch a glimpse of the card on top of the deck before it is dealt to you. You see that it is red. The fact that it is red confirms the hypothesis that the card is the Jack of Hearts, and the hypothesis that it is the Jack of Hearts entails that the card will be a Jack. However, the fact that the card is red does not confirm the hypothesis that the card will be a Jack.[14] There is strong evidence for the existence of electrons, and the existence of electrons entails that there are physical objects; however, it does not follow that there is a strong evidence for the existence of physical objects.

5. Is violating methodological naturalism a science-stopper?

Another popular way to defend methodological naturalism is to shift from a thesis about *propositions* to one about *people*. Instead of discussing the propositions that creationism entails, we are asked to consider the effect that abandoning methodological naturalism would have on people. The claim is that violating methodological naturalism is a "science stopper".[15] If we allow ourselves to talk about supernatural entities, we will stop doing serious science; the methodological principle is said to be a necessary prophylactic. To evaluate this argument, let's begin with a simple historical point. Many central figures in the Scientific Revolution thought that science needs God to explain some natural phenomena. For

[14] See Sober (2010a) for a simple explanation of why the Special Consequence Condition is mistaken within a Bayesian framework.

[15] The label for this argument is from Plantinga (1996); the argument is advanced in Pennock (1999, 292) and in Miller (2007).

example, Newton thought that the solar system would collapse without divine intervention. Newton did not always follow the precepts of methodological naturalism in his work, but this did not prevent him from doing good (or great) science. What is true about the science-stopper argument is that if you use "God wanted things to be so" as your *one and only* response to all the observations you make, you'll never do serious science. But the same is true of an obsessive devotion to the proposition "all events happen because carrots are orange." If you believe that this is the *one and only* explanation of what occurs, *that* will stop you from doing serious science. However, that is no reason to prohibit scientists from mentioning the color of carrots. Introducing God into science does not *necessarily* shut down the whole show, although it will do so if it is carried to monomaniacal extremes (as will any *idée fixe*).

Newton's belief that the stability of the solar system is due to divine intervention did not stop him from doing great scientific work on the law of gravitation. This shows that you can introduce God to explain *X* and still do good science about *Y*. But doesn't saying that God explains *X* rule out doing serious scientific work on why *X* is true? It need not. A scientist can believe that everything that happens in nature happens because it is God's will and still try to discover naturalistic explanations for natural phenomena. It may be replied that introducing the existence of God in this way is scientifically idle. Maybe so, but that does not show that invoking the existence of God must bring science to a stop.

My argument depends on a distinction — between saying "God did it" as *part* of an explanation and saying this as one's *entire* explanation. The latter practice, if generally adopted, would spell the end of productive science. But that does not show that the former would also be lethal. This is why the science-stopper argument fails to justify methodological naturalism.

6. If numbers, why not God?

Mathematics is a necessary framework for science. Many of the scientific theories we prize presuppose that numbers exist. No such argument has been produced for including mention of God in scientific theories. Indeed, there have been many predictive scientific theories, developed over several centuries, that are silent on the question of whether God exists; these provide ample evidence that *science does not need the God-postulate*. These "silent theories" can be supplemented; one can add to them the claim that God exists, or the claim that he does not, or the claim that we don't know whether there is a God, but in each case the supplements aren't consequences of the science; rather, they are philosophical add-ons.

Arguments against introducing the claim that God exists into scientific theories have often been *in-principle*; they attempt to show that this postulate *necessarily* prevents science from reaching one of its goals. For example, it is claimed that the resulting theories cannot be tested or that introducing the God-postulate precludes the development of naturalistic explanations. The argument I would offer is more modest. Naturalistic science has been a success. Nature has presented us with scores of problems that have been addressed successfully by theories that are theistically neutral. We know, by inspecting the history of science, that theism is not needed. The modest defense I would offer of methodological naturalism is simply this: *if it isn't broken, don't fix it.*

One glib retort to this suggestion is that science is *already* broken, and so it *does* stand in need of fixing. This response stems from expecting science to do more than it is capable of doing. If you want scientific theories to tell you what is right and what is wrong, or what the meaning of life is, you will be disappointed. But this does not mean that *science* has failed. Science is not in that line of work; it is a misplaced *scientism* that holds that all meaningful questions can be answered by science and by science alone. This is what Huxley (1892) meant by "scientific naturalism" and what the positivists aimed to defend by way of their testability theory of meaning. It is worlds away from the methodological naturalism that I am defending.

Could a new form of inquiry be pursued in which theories are constructed that are both empirically successful and also are committed to the existence of God? There is a trivial way to do this. Just take a theory that we now admire, one that is theistically neutral, and append to it the statement "and this is God's will." The result is "theistic science," but the theistic add-on is doing no real scientific work. It is idle. The same trick can be used to construct an atheistic science, and the atheistic addition is also scientifically idle. There is a second way of creating a theistically committed scientific theory that also is trivial, but in another way. Consider a theistically neutral theory T that happens to say nothing about the empirical proposition E. Let's add to T the postulate "God wanted T to be true, but ensured that E would be false." Now the theistic add-on *does* say something about nature that the initial theory T failed to address. Even so, the new, augmented theory is not interesting. If you want to find out whether E is true, why not just investigate this directly? Why do so by appending the hypothesis "God wants E to the false" to a theory T that says nothing whatever about E? It is obscure how a theistically committed science could proceed in which the theism is not idle. Is it reasonable to expect that a theistically committed science, or shmience, will be better than the science we now have? It certainly could be a lot worse.

To modern scientists, it may seem obvious that science needs mathematics, but does not need theology. But like all marriages and divorces, these two have their histories, and what seems inevitable after the fact need not have seemed inevitable before. One reason that methodological naturalism became more and more persuasive over hundreds of years was that naturalistic explanations increased in number and power. But the triumph of methodological naturalism had another source; theists developed a theological picture according to which a benevolent deity made the world in such a way that methodological naturalism would turn out to be a successful research tool. This is the idea to which Darwin (1859) appealed when he began the *Origin* with a quotation from his mentor William Whewell:

> But with regard to the material world, we can at least go so far as this – we can perceive that events are brought about not by insulated interpositions of Divine power, exerted in each particular case, but by the establishment of general laws.

Methodological naturalism was promoted by scientists *and* religionists; in fact, the same people often played both roles at once (Numbers 2003).

When he heard Laplace's exposition of the nebular hypothesis (a Newtonian explanation of the origin of the solar system), Napoleon was taken aback. "Where is God in your theory?" he asked, and Laplace is said to have replied that he had no need of that hypothesis. Many of Darwin's contemporaries were shocked that he did not appeal to the direct activity of a designing deity to explain organic diversity. Darwin could have said what Laplace said; in fact, he did say as much. Atheists may want to reach for Ockham's razor at this point and argue that these theories are evidence against the existence of God precisely because these theories show that the God hypothesis is not needed in science. But the inference from "science can explain phenomenon *X* without invoking the existence of God" to "God does not exist" is shaky (Sober 2010b). It also is true that science can explain why gold melts at a certain temperature without postulating the existence of dinosaurs, but that isn't evidence that there were no dinosaurs. We need to attend to Monod's good advice: "any confusion between the ideas *suggested* by science and science itself must be carefully avoided." For some people, Newtonian theory and Darwinian theory *suggest* that there is no God. However, this is not what these theories say; it is a philosophical interpretation that requires additional premises. Molière's M. Jourdain was astonished to learn that he had been speaking in prose for so many years. We should not be astonished, when we discuss science, to find that we are actually doing philosophy.

Acknowledgments

My thanks to Glenn Branch, Joshua Filler, Gerald McKenna, David Miller, Bradley Monton, Ronald Numbers, Robert Russell, and William Stoeger for useful discussion.

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