In Defense of Methodological Naturalism

By Patrick McDonald and Nivaldo J. Tro

Even non-Christians . . . [know] something about the earth, the heavens, and the other elements of this world, about the motion and orbit of the stars and even their size and relative positions, about the predictable eclipses of the sun and moon, the cycles of the years and the seasons, about the kinds of animals shrubs, stones, and so forth . . . . Now, it is a disgraceful and dangerous thing for an infidel to hear a Christian, presumably giving the meaning of Holy Scripture, talking nonsense on these topics; and we should take all means to prevent such an embarrassing situation, in which people show up vast ignorance in a Christian and laugh it to scorn.—St. Augustine, *De Genesi ad Litteram*, IV.23.

Introduction

A number of recent debates within the dialogue between science and religion depend on the admissibility of direct supernatural actions as explanatory elements within scientific theories. On the one side of the debate are those who argue that there is no good reason to exclude God from scientific explanations. For example, Alvin Plantinga says that Christians should practice *theistic science*—they should bring "all that they know as believers" to their scientific work.[1] Since Christians know that God has acted supernaturally within the natural world, supernatural action can be included justifiably into relevant scientific theories. Similarly, intelligent design (ID) theorists such Stephen Meyer and William Dembski argue in favor of the inclusion of supernatural elements within science. According to ID theorists, the current laws of chemistry and physics are insufficient to explain the origin of information within the genetic code and the existence of irreducibly complex structures, such as the bacterial flagellum, within living organisms.[2] Given

In this paper, **Patrick McDonald** and **Nivaldo J. Tro** argue that all scientists, including theists, should practice science in accord with *methodological naturalism*, the idea that scientific theories should be naturalistic (they should not contain supernatural elements). They present several reasons for accepting methodological naturalism, including its proven historical success, and they argue also that such a practice need not imply *metaphysical* naturalism (the idea that only the natural exists). In fact, they suggest that there might be good theological and apologetic reasons to accept methodological naturalism. Mr. McDonald is Associate Professor of Philosophy at Seattle Pacific University and Mr. Tro is Professor of Chemistry at Westmont College.

the shortfall of naturalistic scientific theories in explaining these phenomena, and given our verifiable knowledge that intelligent agents have the ability to create information and to produce irreducibly complex structures, we should posit intelligent design as the scientific explanation. Although the intelligent designer is not identified formally in ID theory, generally it is accepted that the designer most worthy of consideration is God.

On the other side of the debate are both theists and nontheists who question the appropriateness of supernatural elements within scientific theories. Christians including Howard van Till, Robert Pennock, Robert O'Connor, Ernan McMullin, and Kenneth Miller argue that scientists, including Christian scientists, should practice *methodological* naturalism in doing science; that is, they should include only naturalistic explanatory elements in scientific hypotheses and theories.[3] However, for them, the practice of methodological naturalism in science need not commit the Christian to *metaphysical* naturalism (the idea that only the natural exists).

In this paper, we add our own voice, from a Christian perspective, to the defense of methodological naturalism. Specifically, we argue that hypotheses that include supernatural or nonphysical elements as explicit explanatory entities generally have not been successful—they have not done much of the real explanatory work, nor have they had much staying power—in the history of modern science. In contrast, naturalistic hypotheses have been extremely successful, even when introducing radically new ideas such as indeterminism. Further, the shift toward naturalistic theories was not made by atheists acting on their metaphysical commitments (as often is implied by those opposing methodological naturalism), but often by theists, who were driven to methodological naturalism because it worked. We will argue also that there are good biblical, theological, and apologetic reasons for Christians to practice science naturalistically. In other words, we question

[1]Alvin Plantinga, "When Faith and Reason Clash: Evolution and the Bible." *Christian Scholar's Review* 21.1 (1991), 29.

[2]Michael Behe, *Darwin's Black Box* (New York: The Free Press, 1996); William Dembski, *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence* (Lanham, MD: Rowman & Littlefield, 2002); *Debating Design: From Darwin to DNA,* eds. William Dembski and Michael Ruse (Cambridge: Cambridge University Press, 2004); Stephen Meyer, "The Origin of Biological Information and the Higher Taxonomic Categories," *Proceedings of the Biological Society of Washington* 117.2 (2004), 213-39; Stephen Meyer, "The Return of the God Hypothesis, " *Journal of Interdisciplinary Studies* XI.1/2 (1999), 1-38.

[3]Ernan McMullin, "Plantinga's Defense of Special Creation," *Christian Scholar's Review* 21.1 (1991), 55-79; Kenneth Miller, *Finding Darwin's God* (New York: Cliff Street/HarperCollins, 1999); Robert C. O'Connor, "Science on Trial: Exploring the Rationality of Methodological Naturalism," *Perspectives on Science and Christian Faith* 49 (1997), 15-30. Robert T Pennock, "Naturalism, Evidence, and Creationism," in *Intelligent Design Creationism and Its Critics* ed. Robert T. Pennock (Cambridge, MA: The MIT Press, 2001). Van Till makes his argument for methodological naturalism indirectly in defending his notion of a robust formational economy principle – that is, the notion that God has bestowed upon the Creation the capacities to bring forth those systems, events, and individuals that we consider part of nature. See Howard Van Till, "The Creation: Intelligently Designed or Optimally Equipped?," in *Intelligent Design Creationism and Its Critics*, ed. Robert T. Pennock (Cambridge, MA: The MIT Press 2001).

whether there are any good theological reasons to expect science to be "theistic" in its methods in the first place.

We want to be clear from the onset that we are not arguing that methodological naturalism is a necessary condition for science.[4] We judge with many other critics that it is not. There are no clear a priori reasons to exclude the supernatural from science. Nevertheless, methodological naturalism has earned its place as a helpful framework within the practice of science. In other words, methodological naturalism is itself an empirically validated methodology and as such should be honored unless and until a better framework comes to the fore. Theistic science and the intelligent design movement have not given sufficiently good reasons thus far to abandon methodological naturalism. We want also to be clear that we have no interest in trying to define science, per se. However, we are interested in exploring the methodologies within science that have been successful and those that have not. It seems reasonable to assert that successful methodologies deserve a more honored place at the table than those methodologies that are yet unproven. For example, in making decisions regarding science funding and science education, previously successful methodologies should be given preference over those that have, at least to date, proven to be less successful.

Survey of the Recent Literature

Much, though not all, of the debate over methodological naturalism has been centered upon a narrower understanding of methodological naturalism than we defend here. In a recent paper, Del Ratzsch catalogued a range of competing definitions of methodological naturalism nicely.[5] He shows that there is a tendency among the defenders of methodological naturalism—and even among some of the critics, including himself—to portray methodological naturalism as an essential or

[4]In the 1981 case, *McLean v. Arkansas Board of Education*, Creation Science was judged to be "unscientific" by appeal to a certain definition of science. This "definitional" approach has come under severe criticism by a number of critics, some Christian, some not professedly Christian. Judge William R. Overton decided against admitting Creation science into Arkansas schools because it did not meet the following definition of science. To be scientific, an enterprise must: 1) be guided by natural law; 2) be explanatory by reference to natural law; 3) be testable against the empirical world; 4) adopt tentative conclusions that are revisable; and 5) be falsifiable. There have been a host of responses to this "definitional" approach. Both Larry Laudan and Philip Quinn formulated cogent responses to the Ruse-Overton program See Phil Quinn, "The Philosopher of Science as Expert Witness," in *Science and Reality*, eds. James Cushing, Gary Gutting, and Neil Delaney (Notre Dame, IN: University of Notre Dame Press, 1984), and Larry Laudan, "Science at the Bar: Causes for Concern," *Science, Technology, and Human Values* 7 (1982), 16-19. As a set of necessary and sufficient conditions for an inquiry to be called science, it fails. Creation science, theistic science, and ID all make claims of some sorts that can be tested. However, mere testability is not itself a sufficient reason to call something good science, worth taking seriously as a competitor to contemporary explanatory strategies.

[5]Del Ratzsch, *How Not to Critique Intelligent Design Theory* (2005); available from http://www.ArsDisputandi.org, accessed July 15, 2006.

definitional aspect of science. As Eugenie Scott puts it,

> In doing science, one has to proceed as if there were no supernatural interference in the operations of nature. This has worked remarkably well, resulting in an ever-expanding amount of knowledge of how the universe works. . . . Philosophical materialism should not be confused with *methodological materialism*, which is a practical rule for how to do science. In this paper, I will be speaking of science as an epistemology, not as a philosophy. Science is a way of understanding the natural world, using natural forces and processes. Period.[6]

A similar understanding is offered by Ernan McMullin in the pages of this journal in response to Plantinga's first major call for theistic science: "[M]ethodological naturalism does *not* restrict our study of nature; it just lays down which sort of study qualifies as scientific . . . Scientists have to proceed in this way."[7] Many criticisms of methodological naturalism (by Meyer, Dembski, Plantinga, J. P. Moreland, and Ratzsch) aim to undermine this sort of definitional or "prohibitionist" approach. We grant that this approach fails as it is stated. However, a slight change in language makes a significant difference in the discussion of methodological naturalism. To us, the question is not whether science by definition excludes the supernatural, but rather whether supernatural elements within scientific theories have had any lasting value. If it can be shown that they have not, then by induction we can rationalize the continued reliance on methodological naturalism as a guide for scientific inquiry.

Before we move on, we want to clarify that we have no argument with those Christians who want to bring "all they know" into their scientific practice in a weak sense. Honest and genuine Christian conviction should inform what we do in non-trivial ways. For example, when we evaluate the scope of evolutionary explanations, especially with regard to human nature, we Christians will view the discussion from a different viewpoint than non-Christians and non-theists. We may well be skeptical of some of the claims of total explanation offered by evolutionary theories of human origins or of evolutionary psychological theories of human sexuality, for example. We may be highly motivated to ask tough questions and explore theoretical alternatives that fit better with traditional Christian assumptions about human nature. This can all proceed substantively and productively without explicitly invoking Christian doctrines or the action of supernatural agents to defend the scientific investigations under way.[8] Yet this falls short of what theistic science advocates suggest. They propose that doctrines of theistic faith and direct supernatural action can play a substantive, public, and epistemically rich role in the

[6]Eugenie C. Scott, *Science Religion and Evolution* (200); available from http://www.ncseweb.org/, accessed December 15, 2005.
[7]McMullin, "Plantinga's Defense of Special Creation," 168.
[8]Mikael Stenmark argues this point well; see Mikael Stenmark, "Should Religion Shape Science?," *Faith and Philosophy* 21. 3 (2004), 487-505. Worldview considerations, such as Christian belief, may sensibly guide which issues one deems worthy of a serious second (and maybe third) look.

enterprise of science. This would indeed violate methodological naturalism as a framework.

Alvin Plantinga's Analysis of Methodological Naturalism

We can locate the beginnings of the recent debate on methodological naturalism in an exchange that appeared in the pages of this journal in September 1991. In a theme issue entitled "Creation/Evolution and Faith," Plantinga penned an article that has received a fair bit of attention as a shot across the bow of methodological naturalism. In the same issue, a pair of Christian defenders of evolution and methodological naturalism, Plantinga's colleague at the University of Notre Dame, philosopher Ernan McMullin, and Calvin College physicist Howard van Till, responded at length to Plantinga's essay. Plantinga wrote a lengthy point-by-point counter response. Then he followed this up with a series of essays that continue until his more recent debate with Robert Pennock.[9]

Plantinga formulated a sophisticated critique of evolutionary naturalism in the *CSR* article that he has since updated in a number of ways. Plantinga argues that Christians have been too quick to revise a traditional reading of Scriptural texts (not just Genesis) and to revise traditional Creation theology in order to accommodate features of evolutionary biology to a Christian world-view. He shows successfully that, given the lack of clarity on certain points in Scripture and the weight of the evidence from science, parts of the so-called Evolutionary synthesis model are perfectly reconcilable with Scripture. However, other parts of the model are not so reconcilable. For example, according to Plantinga, the thesis of common ancestry (TCA), that all living kinds (including humans) are descended from a common ancestor, is suspect. In Plantinga's view, Scripture seems to teach Special Creation quite strongly. In fact, it teaches it strongly enough that, given Christian theism coupled with Scripture and the empirical evidence relevant to TCA (fossils, comparative anatomy, vestigial organs, bio-geographical distribution of life, or taxonomies built on molecular biological structures, and so forth), Special Creation is more likely than a naturalistic version of TCA.

This example illustrates what is for Plantinga a centrally important point. The empirical evidence cited in favor of a scientific theory such as the neo-Darwinian synthesis must be interpreted relative to a complex set of background beliefs. In the contemporary discussion of evolutionary theory, two of the major sets of background beliefs are theism and naturalism. For naturalists (metaphysical or methodological), a Special Creation hypothesis is not a live option. Given those limitations, neo-Darwinian accounts appear highly likely, in light of the reasonable (possibly even "very good") fit with the range of evidence. However, argues Plantinga, if the beliefs of Christian theism are considered as a relevant background, includ-

[9]These are both published in Robert T. Pennock, ed., *Intelligent Design Creationism and Its Critics* (Cambridge, MA: The MIT Press, 2001).

ing the Special Creation hypothesis, then the neo-Darwinian synthesis no longer looks to be the clear winner. The lesson, according to Plantinga, is that Christian theism makes a signal difference with respect to the evaluation of important scientific hypotheses. Consequently, Christians should outline a scientific research program that not only leaves open the possibility that empirical evidence could suggest design (the central claim of the Intelligent Design movement), but also that central beliefs of Christian theism are allowed explicitly to play a role as guiding "background beliefs" in the evaluation both of scientific evidence and scientific hypotheses and theories.

Metaphysical Presuppositions of Science

Some philosophers have argued that theistic science is better than methodologically naturalistic science because it accounts better for certain metaphysical assumptions that successful science needs to make.[10] The argument is worked out in some detail, but it begins with the observation that science rests upon a number of metaphysical hypotheses. For example, science requires confidence in induction, use of logic and mathematics, belief in an external world, and confidence in the reliability of observation. These assumptions themselves are not derived empirically, nor are they falsifiable or made legitimate by science itself. If science rests on such metaphysics, and if theism grounds the relevant assumptions better than the alternative background view (such as naturalism), then theism should be a part of science (or at least should not be prohibited from science). Of course, a full response to this argument would require a paper of its own. However, the basic arguments can be dealt with rather quickly. Modern science may need to rely on many of the above assumptions, but scientists either agree on this point, so it is not a matter of debate, or they agree that settling such philosophical issues is tangential to their specific scientific questions. Scientists, for the most part, seem reasonable in the common acceptance of the basic rules of logic, in the use of mathematics in science, and in belief in the existence of an external world. They also seem reasonable in leaving it to philosophers to debate about the ultimate nature of and foundations for each of these domains. Scientists seem to have recognized long ago that their work does not depend on settling the philosophical status of these metaphysical assumptions. So there is not an apparent need for a theistic science even if such assumptions are necessary parts of the foundations of science. There might be a case to be made, if J. P. Moreland and Del Ratzsch are correct, for a

[10]J. P. Moreland, "Theistic Science and Methodological Naturalism," in *The Creation Hypothesis: Scientific Evidence for an Intelligent Designer,* ed. J. P. Moreland (Downers Grove, IL: InterVarsity Press, 1994); J. P. and William Lane Craig Moreland, *Philosophical Foundations for a Christian Worldview* (Downers Grove, IL: InterVarsity Press, 2003); Del Ratzsch, *Nature, Design and Science: The Status of Design in Natural Science* (Albany: SUNY Press, 2001); Del Ratzsch, "Stenmark, Plantinga, and Scientific Neutrality," *Faith and Philosophy* 21.3 (2004), 353-64.

theistic *philosophy* of science. However, even this is something much debated in the philosophical community. At the end of the day, their concerns are philosophical and should be handled as philosophical inquiries. In addition, even if these assumptions were shown to fit better with theistic foundations, theistic foundations do not imply theistic science in and of themselves, as we argue later in this paper.

Ratzsch on Hyperflexibility

Ratzsch addresses the charge that supernaturally-based principles are hyperflexible and thus are not very helpful empirically. By "hyperflexibility" we mean that the "theory" can fit any conceivable set of data and thus is underdetermined radically by the data. Good scientific theories like Newtonian mechanics and Neo-Darwinian evolutionary theory are able to adapt to many distinct and incompatible sets of data. By appropriate adjustments in auxiliary assumptions, one can fit the theory to new challenges without gutting the heart of the theory. However, this comes at a cost. One has to pay the price of simplicity at times, or postulate added entities (new planets for example), or complicate assumptions about disturbing conditions (for instance, the complicated story of fossilization). These adjustments themselves should lead to new predictions that may or may not be confirmed later. With such theories we have impressive flexibility, but not hyperflexibility. At some point the "compromises" may become so severe that the relevant community searches for alternatives. Ratzsch concludes from his argument about hyperflexibility that, for example, the ability to account for virtually any contingent evolutionary pathway does not count against evolutionary theory.[11] Therefore, he argues, the mere possibility of explaining virtually anything in terms of supernatural design theories should not count against them. Ratzsch does note that there is a real problem if a theory is hyperflexible at the wrong level. Has nature been given a real opportunity to say no? He adds: "For design theories to face difficulty here it must be established both that they are irreparably hyperflexible and that they exhibit this hyperflexibility at the problematic levels. I know of no attempts to do that."[12] He adds also that barring supernatural theories from science as a policy deprives nature of the chance to say no to "design." This endangers the self-correcting character of science and ironically may turn naturalism into a hyperflexible principle with all that problems that would have.

Meyer and Dembski

So much has been written on the intelligent design debate that it would be impossible for us to summarize all of the issues here. What concerns us is the putative case made by ID advocates for suspending methodological naturalism which

[11]Ratzsch, *Nature, Design and Science: The Status of Design in Natural Science,* 114.
[12]Ibid., 114.

focuses on two main points. The first is that methodological naturalism is an arbitrary limitation upon the explanatory resources of science. The second is that invocation of the supernatural is simply an extension of the kinds of arguments that reputable science already engages in. The first sort of argument we will engage directly in our case studies below. The second argument will be addressed indirectly by the case studies and more directly later in the paper when we discuss a few of the basic conceptual reasons for why a Christian might adopt methodological naturalism.

In addition to repudiating methodological naturalism directly, Meyer has argued also that the historical sciences in particular adopt a structure of inference that is similar to many design hypotheses.[13] The historical sciences, such as evolution, make inferences to best explanations. In the case of the emergence of information as a historical pattern, the best explanation is a designer who either created directly or who brought about the right laws and initial conditions for creation to emerge. Either way, design is a warranted inference.

Dembski argues that there is a clear probabilistic argument that indicates design.[14] The existence of instances of complex specified information (CSI) indicates design reliably if it meets the requirements of the so-called design filter. Instances that seem to meet this requirement include the origin of life, the existence of the cilium and the bacterial flagellum, and maybe the existence of the blood-clotting system and the origins of the Cambrian phyla. Dembski adds a further crucial premise: natural processes are, in principle, incapable of explaining the emergence of such CSI biological forms. However, those forms are here and something must explain them. Thus, the best explanation is a supernatural designer. If we accept such design inferences in other domains, we ought to accept them in this one.

As we have already suggested, if the range of apparent "naturalistic" approaches to the origins of life and to the emergence of novel forms within the history of life prove to be dead-ends, then giving up on methodological naturalism might make sense. However, the design alternative has two conditions to fulfill before it can make that case. The first is to establish that design concepts are an inherently useful part of inquiry into the emergence of novel biological forms. The second is to show that plausible naturalistic approaches are in fact dead-ends on a wide scale. If naturalistic projects did not have a well-established track record, then there might be good reasons to be open-minded. However, as we will show, the two broad approaches to science (naturalistic and non-naturalistic) have been employed in a sort of head-to-head competition over the past few centuries in science. Supernatural approaches have proven to be ineffective while naturalistic

[13]Stephen Meyer, "The Origin of Biological Information and the Higher Taxonomic Categories"; Stephen Meyer, "Qualified Agreement: Modern Science and the Return of the God Hypothesis," in *Science and Christianity: Four Views*, ed. Richard F. Carlson (Downers Grove, IL: InterVarsity Press, 2000); Meyer, "The Return of the God Hypothesis".
[14]Dembski, *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence;* Dembski and Ruse, eds., *Debating Design: From Darwin to DNA.*

approaches have had a long string of successes. Therefore, ID proponents have to overcome the now warranted prejudice against explanatory strategies that violate methodological naturalism. To date, they have not succeeded in doing so.

Three Case Studies on the Supernatural Within Science

Although attempts to demarcate science from non-science have been problematic at best (as we have noted already), and although it has been shown that a variety of factors play important roles in the acceptance of one scientific theory over another, most modern scientific theories have at least some level of empirical accessibility.[15] By this we mean that observation and experiment can and do play a significant role in deciding between the validity of competing scientific theories. We do not claim that supernatural elements within a theory render it empirically inaccessible. For example, we can form a theory in which ghosts explain the noises heard in an abandoned house. We can claim further that these ghosts leave some sort of measurable energy signatures. We can then embark on a research program to measure the energy signatures and therefore find empirical evidence for these ghosts. We are not claiming that such a research program is not scientific—to our minds, it is. However, we are claiming that such a research program is ill-advised on the basis of the past history of ghost-claims. In the case studies that we present here, supernatural elements were a part of proposed scientific theories. The question we wish to explore is whether these elements had any lasting explanatory power.

Case 1: Seventeenth-Century Science and Isaac Newton

A number of critics of methodological naturalism have suggested that important founders of modern science including Johannes Kepler, Robert Boyle, and Isaac Newton introduced supernatural elements into their models.[16] For example, Meyer concisely traces the history of the design tradition in Western thought from Plato and Cicero in antiquity to Maimonides, St. Thomas Aquinas, Robert Grosseteste, Roger Bacon, and Duns Scotus in the late Mediaeval period, to some of the major players in the Scientific Revolution such as Kepler, Boyle, and Newton. Meyer says, "this tradition attained almost majestic rhetorical quality in the writing of Isaac

[15]The *locus classicus* for such a discussion is Thomas Kuhn, *The Structure of Scientific Revolutions*, 2nd ed. (Chicago: University of Chicago Press 1970). See also the following responses to some of Kuhn's theses: Imre Lakatos, "Falsification and the Methodology of Scientific Research Programs," in *Criticism and the Growth of Knowledge*, eds. Alan Musgrave and Imre Lakatos (Cambridge: Cambridge University Press, 1970); and Ernan McMullin, "The Shaping of Scientific Rationality," in *Construction and Constraint*, ed. Ernan McMullin (Notre Dame, IN: University of Notre Dame Press, 1988).

[16]Ratzsch, *Nature, Design and Science: The Status of Design in Natural Science*; Ratzsch, "Stenmark, Plantinga, and Scientific Neutrality"; Meyer, "Qualified Agreement: Modern Science and the Return of the God Hypothesis."

Newton (1642 – 1727)."[17] Meyer observes that in the "General Scholium" to the *Principia,* Newton argued that the planetary system's stability was a function of both universal gravitation and the precise initial positioning of the planets and comets in relation to the sun. He quotes Newton:

> Though these bodies may, indeed, persevere in their orbits by the mere laws of gravity, yet they could by no means have at first derived the regular position of the orbits themselves from those laws. . . . [Thus] this most beautiful system of the sun, planets, comets, could only proceed from the counsel and dominion of an intelligent and powerful being.

Meyer concludes that "for Newton and other like-minded early modern scientists, observable evidences in nature testified to an unobservable and intelligent Designer whom they identified with the God of the Judaeo-Christian Bible."[18] However, sometime in the last 200 years or so, scientific discourse has become much less hospitable to the explicit invocation of theistic principles. Ratzsch observes:

> There is currently nearly unanimous agreement that reference to the supernatural—and that includes divine intelligent design—is completely out of place in scientific contexts. But the illegitimacy of the supernatural in science certainly wasn't obvious to many major historical figures in science. Some, such as Newton, made explicit reference to divine activity and design in their scientific theorizing, and the theology of others, such as Boyle, Maxwell, Faraday, and Herschel, played formative roles in the shaping of their scientific theories. Obviously, views concerning the boundaries of scientific legitimacy have shifted substantially. What underlay that shift?[19]

Let us consider briefly the European context in the 17th and 18th centuries. First, the term "science" did not exist—the term "*scientia*" did of course, but its meaning, "demonstrated knowledge," had a different connotation than does the term "science" in the English-speaking world today. It is clear that much of the work of Kepler, Newton, Boyle, Galileo, Robert Hooke, Christian Huygens, René Descartes and others looks much like what we would call science today. However, much of what they did looks like what we today call philosophy. For now, let us simply take the work of Kepler, Boyle, Newton, and others as we find it. We need not decide which parts of their work belong properly to science and which to philosophy or theology. Nevertheless, we may be able to discern more or less clearly which parts of their work endured as models of what came to be more commonly called science.

Clearly Newton drew inspiration from his faith in the pursuit of his inquiries into nature and did indeed discuss the role of God in nature. Nonetheless, his methodological and technical achievements set into accelerated motion a self-confident program of increasingly technical physical inquiry that within a century had fairly clearly established its methodological autonomy from theistic considerations, even if not from metaphysics in all forms. The legacy of Newton speaks

[17]Meyer, "Qualified Agreement: Modern Science and the Return of the God Hypothesis,"133.
[18]Ibid., 133-34.
[19]Ratzsch, *Nature, Design and Science: The Status of Design in Natural Science*, 79.

much more strongly in favor of the power of naturalistic methodology than for theistic science. In other words, even though Newton may have relied on his theistic beliefs to formulate his ideas, those beliefs were not the part of his work that endured.

Let us look briefly at Newton's *Principia*. Newton's Preface states clearly that he wants nothing to do with "occult qualities." While Newton did not dissolve all mystery from science successfully, he intended to continue the development of tools to articulate problems that admit of reasonably clear adjudication. Three principles stand out in his approach. The first is the careful building upon what by then had become a rich set of observations about the motions of the celestial orbs as well as motions of terrestrial objects. These observations had been formulated into patterns such as Kepler's laws and Galileo's law of free fall. The second is the development of the tools of exact mathematical description in connection to problems in mechanics. The third is a continuation of a process of concept formation and refinement regarding matter, motion, force, and the proper analysis thereof that made possible the achievements not only of the *Principia* and the *Opticks*, but also the explosion in the 18th century of rational mechanics. These three principles are unified by a commitment to precision and tractability. As Richard Westfall observes in his concluding statement of *Construction of Modern Science*, Newton was willing to admit that the internal side of nature is mysterious.[20] However, he demanded that what we investigate be based upon exact descriptions of phenomena and lead to an exact treatment.

Newton's actual physical inquiry in the *Principia* makes little use of God as an explanatory hypothesis. He does speak more extensively about God's role in the "Queries" of the *Opticks*. However, the cores of his natural philosophical proposals do not make direct appeals to God as an explanatory hypothesis. He spends far more time working out the details of the notions of force and the mathematical analysis thereof. God enters his picture only when the exact inquiry of natural philosophy has come to an end (when it has shown its limits in providing the fundamental explanation). Clearly, Newton makes implicit appeal to his own faith in assuming an orderly, intelligible universe designed by God's providential hand. This supports his confidence in our ability to know it, to represent systems mathematically, to uncover forces through experiments, and to generalize our insights into cause-effect relations through induction. But the real action of what we might call Newton's science seems to be in the hard work of observation, experiment, conceptual development of novel physical concepts (inertia, matter, force), and mathematical analysis.

This understanding of Newton's work seems borne out in the rhetoric of the "General Scholium," published for the first time in the 2nd edition of the *Principia* (1713). Newton appears to be responding to criticisms from the likes of Gottried

[20]Richard S. Westfall, *The Construction of Modern Science: Mechanisms and Mechanics* (Cambridge: Cambridge University Press, 1977), 159.

Wilhelm von Leibniz and Huygens that he had revived the discredited tradition of appeal to occult qualities. The seventeenth-century mechanists saw it as a badge of honor to move beyond notions of internal "natures," "affinities" or spirits that do the work of explaining motion, many preferring the model of contact action. One could see, then, the worry about Newton's appeal to forces, such as gravity, not directly accessible to observation and seeming to act at a distance. Furthermore, there seems to have been a suspicion that the Newtonian system hinted of atheism in its attempt to derive all of the phenomena of nature from a basic set of laws and to do so without appeal to direct divine action. This left Newton walking the razor's edge of explaining his vision of the proper role of God in natural philosophy while pleading at the same time for the empirical rigor of his concept of force.

He seems implicitly to have two different notions of warrant (the evidential and cognitive basis for a belief) operating in his work, a weaker and a stronger one. The weaker one concerns knowing God by a partial analogy from knowing nature:

> We know him only by his most wise and excellent contrivances of things and final causes . . . a God without dominion, providence, and final causes is nothing else but Fate and Nature. Blind metaphysical necessity which is certainly the same always and everywhere could produce no variety of things.[21]

Only a providential God could produce such a vast profusion of things suited to local places and times. He adds that we know of God by similitudes taken from the world: "for all our notions of God are taken from the ways of mankind by a certain similitude, which, though not perfect, has some likeness, however." Which is followed immediately by the oft quoted phrase, "And thus much concerning God; to discourse of whom from the appearances of things, does certainly belong to Natural Philosophy."[22] Newton's analogical language here contrasts with the stronger language of "deductions from phenomena" that he uses regarding the warrant for referring to gravitational force in experimental philosophy. Newton was stung by critics such as Leibniz and Huygens who suggested that the postulation of a non-contact force such as gravity failed to explain the cause of interaction and, as put by Leibniz, left unexplained why planets revolve in the same plane in the same direction around the sun. In an exchange of letters, Leibniz suggested to Huygens that a mechanical vortex theory in the Cartesian spirit was still necessary. As Westfall notes, "Leibniz's letters repeated the basic conviction of the mechanical philosophy, that the universe is transparent to human reason."[23] This led to a fundamental crossroads in methodology. Should one press on with a model of clear intelligibility but less analytical power (for example, a version of the mechanical philosophy and contact action), or should one accept Newton's postulation of apparently dis-

[21]Isaac Newton, *Philosophiae Naturalis Principia: Sir Isaac Newton's Mathematical Principles of Natural Philosophy and His System of the World,* trans. Andrew Motte (1729), trans. Florian Cajori (Berkeley: University of California Press, 1962), 546.
[22]*Principia*, 546.
[23]Westfall, *The Construction of Modern Science: Mechanisms and Mechanics*, 157.

tant action forces (possibly explained by an aether pervading the universe or by God's direct action), or should one simply abandon the drive for ultimate causal explanation, resting with an incomplete but effective analytical model?

Newton had hinted at a basic methodological humility in the famous Query 31, published originally with the *Opticks* in 1706. In response to charges that his use of force brought an occult quality back into natural philosophy, Newton explained why this was not the case:

> These Principles I consider, not as occult Qualities, supposed to result from the specifick Forms of Things, but as general Laws of Nature, by which the Things themselves are formed; their Truth appearing to us by Phaenomena, though their Causes be not yet discovered. For these are manifest Qualities, and their Causes only are occult. . . . To tell us that every Species of Things is endowed with an occult specifick Quality by which it acts and produces manifest Effects, is to tell us nothing: But to derive two or three general Principles of Motion from Phaenomena, and afterwards to tell us how the Properties and Actions of all corporeal Things follow from those manifest Principles, would be a very great step in Philosophy, though the Causes of those Principles were not yet discovered: And therefore I scruple not to propose the Principles of Motion above-mentioned, they being of very general Extent, and leave their Causes to be found out.[24]

To be clear, Newton did not back off from the basic propositions that he defended in the *Principia*. There he suggests (perhaps naively) that these laws spring directly from the phenomena, made general by induction. He admits that the ultimate background causes of the gravitational attractive forces are unknown of which he admits, "I frame no hypotheses." He goes on:

> for whatever is not deduced from the phenomena is to be called a hypothesis, and hypotheses whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy. In this philosophy, particular propositions are inferred from the phenomena, and afterwards rendered general by induction.[25]

We do not mean to suggest that Newton offers a narrowly empiricist methodology. These comments do hint, however, at a different attitude about the role of God in the Newtonian program that stands in contrast to the concept of mechanical force. Both involve some unknowns regarding the mode of causal action. However, the concept of force is at least amenable to a precise mathematical representation, that when refined in the 18th century by mathematicians such as Leonhard Euler and Daniel Bernoulli, allowed for a whole host of specific problem-solving endeavors. Debate both about God's role as an explanatory factor and the mode in which natural philosophy could support natural theology continued through to the 19th century. The light of reason could still show that God exists by the beauty and order of His creation. But the mode of argument for that conclusion seems quite different from the mode of argument in defense of the theory of universal gravita-

[24]Isaac Newton, *Opticks*, 4th Ed. (New York: Dover, 1730), 401-02.
[25]Newton, *Philosophiae Naturalis Principia Sir Isaac Newton's Mathematical Principles of Natural Philosophy and His System of the World*, 546-47.

tion. Clearly Newton had a prior commitment to God's existence and plugged a gap in the ability to explain the "fine-tuning" of the solar system with the idea of an active God that he had worked out in his theological reflections. This argument relies heavily on background beliefs and analogy. The argument for universal gravitation also required analogical inferences and new concepts. However, as Newton suggested, it relied heavily upon widely observed regularities in motion and concepts in mathematics (such as inverse square force and elliptical orbits). He seems to accord a stronger warrant to this type of argument. We can see by the echoes of the debate with Leibniz (to some degree carried out by proxy through the Leibniz-Clarke correspondence), that it was very difficult even for fellow Christians (as it is today) to come to agreement about the proper way to model God's action in the world. It was the achievement of the *Principia* to establish a framework for investigating the laws of nature that has achieved consensus and resolution in the community of natural philosophers.

As a post-script to this episode, we may consider briefly the fate of Newton's appeal to God as a source of planetary fine-tuning—that is, setting up the right initial conditions for the planets to remain in stable orbits. Newton's legacy in the 18th century was rich and multifaceted.[26] Appeal to the divine in terrestrial and celestial physics became increasingly rare, as it did in a range of physical and chemical studies. Eventually, Pierre-Simon, Marquis de Laplace (and Immanuel Kant, independently) addressed one of the problems for which Newton had invoked divine fine-tuning. Laplace developed a theory of probability and applied it to the problem that the movements of the planets in the solar system had likely occurred by chance. More specifically, could chance explain the unidirectional movement and rotation of the planets and their satellites? Could chance explain the small eccentricity of planetary orbits and large eccentricity of the cometary orbits? As Roger Hahn has reported, Laplace offered a tentative hypothesis in his *Exposition du Systeme du Monde*, first in 1796 and revised in subsequent editions up to the 4th in 1813. This theory, the so-called nebular hypothesis, grew in detail as Laplace learned of William Herschel's theory of the evolution of nebulae and used this to construct a mechanical theory of the formation of the solar system. Laplace made much of this mechanical theory and in 1813 singled out Newton for a reprimand after outlining the nebular hypothesis. He remarked, "I cannot forgo noting here how Newton strayed on this point from the method that he otherwise used so effectively."[27] Given the relative contexts, Newton's move was entirely defensible,

[26]For discussion, see Roger Hahn, "Laplace and the Mechanistic Universe," in *God and Nature: Historical Essays on the Encounter between Christianity and Science*, eds. David C. Lindberg and Ronald L. Numbers (Berkeley: University of California Press, 1986); Thomas Hankins, *Science and the Enlightenment* (Cambridge, UK: Cambridge University Press, 1985); Margaret Jacob, "Christianity and the Newtonian Worldview," in *God and Nature: Historical Essays on the Encounter between Christianity and Science,* eds. David C. Lindberg and Ronald L. Numbers (Berkeley: University of California Press, 1986).

[27]Hahn, "Laplace and the Mechanistic Universe," 272.

as was Laplace's triumphalism.

Newton introduced a new model of physical inquiry and for explaining motion, yet still found a place for God in his discussion. However, as his model became accepted in various domains and as it developed more exactly, there was less need to appeal explicitly to the divine in the study of motion. The legacy of Newton's contribution seems to be, then, less a model for the intelligent design movement or theistic science than a model for engaging in a science guided by methodological naturalism. Strictly speaking, universal gravitation was just as hypothetical as God's direct intervention. However, he could constrain the former and subject it to a mathematical model that was testable empirically over time. Its success in those tests and ability to provide detailed guidance to further inquiry explains its enduring scientific value.

Case 2: Vitalism

Vitalism—the belief in a vital force that animates living organisms and makes them distinct from non-living matter—has its origins in the writings of Plato and Aristotle and played an important role in the development of modern chemistry and biology through the middle of the 19th century. Early modern vitalists include Johannes Baptista Van Helmont (1579-1644), a Roman Catholic Flemish physician and chemist, and Georg Ernst Stahl (1660-1734), a devout German Pietist who studied chemistry and medicine and is best known for his failed phlogiston theory of combustion. For both of these scientists, the vital force was non-physical and non-material. However, its presence was empirically accessible—for them, empiricism was the way to discover the attributes of the vital force. At a time when the distinction between science and theology was just being forged, the proposal of a non-physical force to explain physical phenomena was entirely familiar.[28]

In the 17th century, Van Helmont postulated that the essence of an object was not the material object itself, but its spiritualized form. Most of his work was focused on searching for the "semina" of beings, the active principle that is responsible for the being's specific form and function.[29] According to Van Helmont, a hierarchy of spiritual directing forces immanent in matter controlled the course of physiology in living organisms. Walter Pagel writes, "the speculation of how the non-corporeal is connected with and acts on matter is the very center of Van Helmont's research that led him to his discoveries."[30] These discoveries were sig-

[28]Much of the following discussion draws from the following sources: Lester S. King, "Stahl and Hoffman: A Study of 18th C. Animism," *Journal of the History of Medicine* XIX (1964), 118-130; Lester S. King, "Basic Concepts of Early 18th C. Animism," *American Journal of Psychiatry* 124 (December 1967), 797-802; Walter Pagel, "The Religious and Philosophical Aspects of Van Helmont's Science and Medicine," *Supplement to Bulletin of the History of Medicine No. 2* (1944), 1-44; L. Richmond Wheeler, *Vitalism: Its History and Validity* (London: Witherby, 1939).
[29]Pagel, "The Religious and Philosophical Aspects of Van Helmont's Science and Medicine," 2.
[30]Ibid., XXX.

nificant and include the first scientific quantitative measurements of mass, an early thermometer, the demonstration that acid was responsible for digestion, and the introduction of the term "gas" in the modern scientific sense. Van Helmont's hypothesis about spiritual forces led him to concepts that had lasting scientific value, but the hypothesis itself was not one of those concepts. His discoveries were a byproduct of his search for the spark of life, not the direct conceptual result of that search.

In the early 18th century, Stahl articulated a vitalist doctrine in which an irreducible difference existed between living and non-living matter. Stahl wanted to explain life against the growing backdrop of the mechanical universe. The mechanical philosophy of Newton and Boyle could explain non-living matter, but, according to Stahl, it could not explain life. Living organisms were composed of matter, but in addition they also possessed anima, an immaterial vital principle that transcended ordinary matter. Anima could not be perceived or studied directly, but its nature could be inferred by studying its effects. It was anima that kept a living body from undergoing putrefaction, and it was anima that directed matter to sustain life. Anima caused the chemical changes that occurred in living organisms to be different from the chemical changes that occurred in non-living matter. Stahl was left with the problem of how an immaterial entity acts on the material world. Stahl used motion as the intermediary. Anima was immaterial but it could cause motion (also immaterial) in matter. In this way, anima was able to carry out its work of directing life.

In the second half of the 18th century, the work of Caspar Friedrich Wolff (1734-1794), a German embryologist, helped cement the belief in vitalism. Before Wolff, the theory of preformation—the idea that the egg cell contained a miniature adult—was dominant in embryology. In 1759, Wolff published his dissertation, *Theoria Generationis,* in which he describes his observation of the gradual differentiation of the parts of a chick embryo from the undifferentiated egg. His work supported the theory of epigenesis (that development is a gradual process of increasing complexity) and marks the beginning of the end of preformation theory. However, epigenesis raised significant questions about how undifferentiated elements developed into a living organism. Instead of putting the miracle of creation at the beginning of the universe, Wolff placed it exactly at the point where his knowledge ended. Wolff suggested that there existed a *vis essentialis corporis*, a vital force that directs the formation of an embryo from its undifferentiated elements to its final form.

Nineteenth-century vitalists include Jons Jacob Berzelius (1779-1848) and Justus Von Liebeg (1803-1873). For these vitalists, the vital force was not a spiritual phenomenon, but a purely physical one. Berzelius was a Swedish chemist who held that the vital force operated only in living organisms and could not be imitated in the laboratory. This idea created a seemingly insurmountable divide between organic compounds, those derived from living organisms, and inorganic compounds, those derived from the earth. Many inorganic compounds had been synthesized in the laboratory, but generally chemists had not been successful in synthesizing or-

ganic ones. Organic compounds required the vital force for their synthesis, and thus would never be made in the laboratory, according to Berzelius.

Even in the early years of the 19th century, increasing research in chemistry was beginning to chip away at vitalistic ideas. For example, some organic compounds were synthesized, although admittedly from organic starting materials. Other vitalistic ideas also came into question. For example, Liebig himself showed that the primary source of body heat was not due to a vital force, but due to chemical reactions in tissues. Liebig admitted that chemists could synthesize organic substances, but asserted that they could never create "an eye, a hair, or a leaf." For the creation of these, a vital force was necessary. However, Liebig's vitalism was different from that of Van Helmont and Stahl. The vital force was not spiritual, but physical. Liebig writes in *Animal Chemistry: "*It cannot be denied that this peculiar force exercises a certain influence on the activity of vegetative life, just as other immaterial agents such as light, heat, electricity, and magnetism do."[31] In a margin note on the same page, he writes, "the soul is no object for physical investigation." Clearly, according to Liebig, the supernatural was out of bounds in scientific investigation.

Vitalism died a slow death in the middle of the 19th century. The laboratory synthesis of a number of organic compounds, especially the synthesis of urea (organic) from lead cyanate and ammonium chloride (both inorganic) by Friedrich Wöhler (1800-1882) in 1828, began to blur the line between organic and inorganic compounds. The discovery of the details of many physiological processes, such as the production of heat by oxidation in plants and the formation of glycogen and sugar in the liver, demonstrated that chemical changes in living organisms could be explained in ways that were similar to chemical changes in inorganic matter. The work of Louis Pasteur (1822-1895) showed that putrefaction and disease were not caused by the absence of the vital force, but by other living organisms that caused these conditions directly.

Developments in physics also aided in the demise of vitalism. In the middle of the 19th century, the work of Julius Rober Mayer (1814-1878), James Joule (1818-1889), and Hermann von Helmholtz (1821-1894) firmly established the law of conservation of energy. The law applied equally to all matter, including living matter. In an 1847 paper entitled, "On the Generation of Heat in Muscle Action," using clever instrumentation and careful experimentation, Helmholtz provided precise quantitative data regarding the energy conversions in muscle contractions. In such systems, chemical reactions produced heat which caused a current in a thermocouple and a resulting deflection of a magnetic needle. These experiments left him confident that organic processes were governed by the conservation of energy.[32]

[31]Justus Freiherr von Liebig, *Animal Chemistry; or, Organic Chemistry in Its Application to Physiology and Pathology*, trans. William Gregory and others. Ed. from the author's manuscript, from the 3d London ed., rev. and greatly enlarged ed. (New York: Wiley & Putnam, 1848).
[32]For a helpful discussion of this episode, see Timothy Lenoir, *The Strategy of Life: Teleology and Mechanics in Nineteenth Century German Biology* (Chicago: Chicago University Press, 1989).

He followed this with the publication of his now-famous 1847 lecture, "On the Conservation of Force (*Kraft*)."[33] Here he provided a rigorous theoretical framework for experimental results concerning the conversions of kinds of forces one to another. This, combined with his application of the argument to living systems, provided a prima facie reason to reject the causal efficacy and existence of constitutive vital powers. If Stahl's anima was influencing living matter through motion, living organisms would violate energy conservation, but no such violation was observed. In other words, the discoveries of the 19th century demonstrated that a living organism behaves like a physical system and must follow the laws of nature. No vital force could nullify these laws. By the end of the 19th century, belief in vitalism had been largely eliminated from the practicing scientific community, not because of an atheistic bent on the part of the community, but because scientists were driven there by the empirical data.

Case 3: Creation Science

Here we take a broad view of creation science, not simply in its recent incarnation, but also in its older tradition of wedding the Scriptural traditions of creation teaching with the empirical study of the origins of living forms. We see here a history of "bringing what we know as Christians" to the study of nature and note that it has had a mixed legacy. When Christians brought their background beliefs—the story of the ark, the Flood, and the re-population of the earth after the Flood—to the study of the history of life and of the earth, two things happened. The first is that they engaged in a great deal of productive investigation, revealing vast stretches of new insights in these domains. However, they revealed also that eventually, the tight link between the Biblical narratives and these historical sciences became a degenerating research program that had no lasting value within science. The resulting lesson seems to be that it is best to pursue natural history and geology within a methodologically naturalistic framework.

Janet Browne has chronicled some of the work of searching for an account of the ark and the flood elegantly in her article, "Noah's Flood, the Ark, and the Shaping of Early Modern Natural History."[34] In the 17th century, knowledge about the age of the earth, geological formations, and bio-geography did not come into direct conflict with a roughly literal interpretation of the days of Creation, the order of Creation, the story of the Flood, and the capacity of the ark to hold all the living kinds it was asked to hold. As the 17th century wore on, natural philosophers, with the idea of confirming the Biblical story, became interested in assessing from a more exact perspective how these events may have occurred. A prime example is

[33]Hermann von Helmholtz, "On the Conservation of Force," in *Selected Writings of Hermann Von Helmholtz,* ed. Russell Kahl (Middletown, CN: Wesleyan University Press, 1847).
[34]Janet Browne, "Noah's Flood, the Ark, and the Shaping of Early Modern Natural History," in *When Science and Christianity Meet*, eds. David C. Lindberg and Ronald L. Numbers (Chicago: University of Chicago Press, 2003).

Athanasius Kircher's (1602 – 1680) *Arca Noë*. In this work, the German Jesuit priest laid out the details of the Noachic deluge carefully in contemporary natural philosophical terms. He used the common cubit (approx. 18 in.) as a measurement and judged that the ark had three decks, with three hundred animal stalls on the lowest, a huge storage hold on the middle deck, and about two hundred bird cages on the top deck. The storage hold on the second deck would have held enough feed for a city of animals and the human accommodations would have been on the top deck with the birds.[35] Kircher was attempting to find reasonable explanations for the ark accommodating 130 different beasts, 30 pairs of snakes, and 150 kinds of birds.

Kircher was not the only naturalist engaged in this enterprise, only one of the better known. Later in the 17th century, the attempts to find room on the ark for the known animals became more sophisticated and more strained. The dilemma for naturalists who wished to interpret the Genesis text in line with tradition and to honor the findings of contemporary discovery was becoming severe. Browne observed that, "Britain's premier natural history cataloguer, John Ray (1628 – 1705), recorded the existence in the known world, of some 500 species of birds, 150 of quadrupeds, and approximately 10,000 kinds of fish and invertebrates of one kind or another."[36] Not only was it becoming increasingly difficult to envision all of this teeming life sharing space on the ark, but also to imagine how all of these distinct kinds made their way effectively and intact from Mt. Ararat upon disembarking from the ark.

As the great Swedish naturalist Carolus Linnaeus (1707 – 78), an orthodox Protestant, went to work on his extraordinary classificatory mission, the situation reached a breaking point. Linnaeus counted, incredibly, over 300 mammals alone, and in his lifetime an incredible total of over 14,000 species. Through the 18th century, naturalists became increasingly skeptical of finding a way to make the traditional interpretation of the ark, the Flood, and the post Deluge re-population of the globe fit the contemporary knowledge of bio-geography. The attitude of the German naturalist Eberhard Zimmerman seems emblematic of this skepticism. In his 1777 work, *Specimen Zoologicae Geographicae Quadrupedum*, Zimmerman ridiculed the idea of a literal ark and a post-Ararat repopulation of the globe. Quickly thereafter, most European naturalists ceased attempts at accommodating a literal account of the ark as the single explanation for the origin and distribution of life forms.[37] The weight of the numbers led Linnaeus to give up on the ark, but not on postulating a mountain, a world-wide "ocean," and pairs of animals migrating from a single geographical point. Between Linnaeus's mid-century work and Zimmerman's work, enough had changed in the intellectual climate so that the latter offered his own alternative account to substitute for the roughly traditional account of migration. He argued that it was more likely that every animal was

[35]Ibid., 115.
[36]Ibid., 120.
[37]Ibid., 137.

created in the area where it was destined to live under the same climate that it now enjoys, adapted to the resources at hand. This idea took root quickly and allowed naturalists to ask other questions.

One of the questions still remaining was the issue of a world-wide flood and whether vestiges of its effects might be found through geological inquiry. By the 1790s, some began to doubt that the Flood was global in scope and thereafter many regarded the Flood as one of a series of upheavals or catastrophes that had taken place in the history of the earth. This led to questions about the age of the earth and the kinds of upheavals that had taken place. The Flood began to be seen as a geological event separating early earth and its pre-human history from the human era of earth's history. In England, a series of impressive treatises in geology spanning from James Hutton through the work of William Buckland to that of Charles Lyell explored these questions. The work of these men tracks the rise and fall of a self-conscious Diluvial Geology inspired by Scripture, but using the tools of an increasingly sophisticated empirical and analytical natural history.[38]

Buckland was both an Anglican priest and an Oxford professor. In his *Vindiciae Geologicae* of 1820, he vowed to demonstrate the importance of geology for showing in detail the remains of the Biblical Deluge. In 1821 he received exciting news about a find of fossil bones in a cave in Kirkdale, Yorkshire. At first it seemed highly plausible that the bones, many of them from tropical animals such as hippopotamus, rhinoceros, elephants, tigers, bears, and hyenas, had been washed up to Yorkshire by the Biblical Flood. However, as Buckland examined the bones carefully, an alternative explanation seemed more likely. Many of the bones had been gnawed with consistent patterns and many of the bones were highly polished. He knew that these matched the findings of bones in dens where predators congregate, gnawing on bones and repeatedly treading on them over time. As Mott Greene observes, soon thereafter, Buckland suggested such an interpretation, "a traveling menagerie came through Oxford with a captive hyena, and Buckland took the opportunity to offer some large bones to the animal to chew."[39] Then he compared the puncture marks and grooves on the bones offered the live hyena with those from Kirkdale and found them to be identical in general pattern. This fact and other features of the cave led Buckland to doubt that this particular set of fossils was the result of a great flood. He thought it more likely to be the result of hyenas

[38]The story of the engagement of Scripture and the formation of geology has been told in detail by C. C. Gillispie, *Genesis and Geology: A Study in the Relations of Scientific Thought, Natural Theology, and Social Opinion in Great Britain, 1790-1850* (Cambridge: Harvard University Press, 1951) and Nicholas Rupke, *The Great Chain of History: William Buckland and the English School of Geology, 1814-1819* (New York: Oxford University Press, 1983). Mott Greene condenses the story nicely and focuses squarely on the work of William Buckland, the founder of modern flood geology. See Mott T. Greene, "Genesis and Geology Revisited: The Order of Nature and the Nature of Order in Nineteenth-Century Britain," in *When Science and Christianity Meet*, eds. David C. Lindberg and Ronald L. Numbers (Chicago: University of Chicago Press, 2003).

[39]Ibid., 142.

actually inhabiting that region in an antediluvian (pre-flood) age and depositing the bones there in the course of living in the cave. Buckland was driven to alternative (non-Biblically based) theories by his observations.

Buckland was indeed comfortable with the idea of a series of antediluvian worlds or ages. Furthermore, he was still intent on vindicating geology as a subject matter worthy of being pursued at a place like Oxford which was then primarily a training ground for future clergy. He would do this by continuing to find evidence of God's providential intervention at some point in earth's history to punish evil and set things aright. In his publication *Reliquiae Diluvianae* of 1823, Buckland developed a kind of template for defending the truth of the Scriptural account that he would rely upon later in his career.[40] He would begin a section of a text by affirming the truth of Scripture, but then move on to give a detailed and largely empirical account of his discoveries as well as those of his colleagues. He came to distinguish the geological evidence very clearly from the historical-theological conclusions drawn therefrom. He concluded that the Flood was not a global cataclysm, affecting all geological strata, but rather corresponded to a world-wide geological marker separating pre-human history from the scripturally recorded history of the earth and its repopulation by divine intervention. Buckland's work changed the framework of Diluvial Geology in three ways: (1) it reduced the portion of the geological record ascribable to the Deluge; (2) it reduced the power of the floodwaters to transport material such as fossil bones; and (3) it undermined the theory that land and sea exchanged "places" in the flood. The hyena den theory of the bones of Kirkdale, and other such finds, suggested to Buckland that, while the dry land in Yorkshire may have had a different climate in the distant past, it had nevertheless been dry land before the Noachian Flood.

Buckland came increasingly to dissociate the details of geology from the details of the Genesis account. In his *Bridgewater Treatise*, Buckland articulates a Gap theory of earth history instead of a Day-Age theory.[41] Both views are consistent with the great age of the earth then becoming common among geologists. However, a Day-Age view saw the days as long ages but still attributed the prehistory of humans to parallel those days and suggested that the details of geological history should match the specific details of the Genesis 1 account of each day. The gap theory sees a major gap of time occurring between Genesis 1:1 and Genesis 1:2. No details are provided there, so none need be made consistent with the details of geological inquiry. Furthermore, in his discussion of the apologetic value of geology, Buckland changed his strategy, as Greene observes, "moving from geology as evidence of providential intervention to geology as evidence of providential design."[42] He concludes that the science and the theology were not inevitably an-

[40]Ibid., 147.
[41]William Buckland, *Geology and Mineralogy Considered with Reference to Natural Theology: Bridgewater Treatises on the Power, Wisdom, and Goodness of God as Manifested in the Creation, Treatise 6* (London, W. Pickering, 1836).
[42]Ibid., 159.

tagonistic, but could be mutually reinforcing. However, to achieve this harmony, it seems that the use of the details of Scripture as a specific evaluative guide was highly attenuated. What was to count as solid geological knowledge became less and less determined by Scripture and increasingly by empirical inquiry and geological analysis. The history of geology from the 1850s until today is an increasingly solid naturalistic enterprise.

In spite of this history, Flood geology regained popularity in the early 1960s when a group of conservative Christian scientists, headed by John Whitcomb (an Old Testament scholar) and Henry Morris (a hydraulic engineer), founded a movement that came to be known as Scientific Creationism or Creation Science. The movement's central idea, like the central idea of geology in the 17th century, is that God created the world supernaturally in six literal Creation days and that empirical data could be marshaled to support this claim. In the foreword to the *Genesis Flood*, Whitcomb and Morris write: "The Bible teaches a unique creation and subsequent world-wide deluge, the major facts of geology and other sciences can be satisfactorily oriented within this framework."[43] Although Creation Science became accepted by a significant number of conservative Christians battling what they saw as an inherent connection between evolution and atheism, it has not proven fruitful as a scientific model and is summarily rejected by the vast majority of practicing scientists (both Christian and non-Christian) in spite of claims by the Institute of Creation Research to the contrary. Their website continues to state that, "creation scientists can now be found in literally every discipline of science, and their numbers are increasing rapidly." We fail to see the rapid increase in their numbers or the general acceptance of any of their models, which were fairly definitively shown to be problematic by the middle of the 19th century.

Afterward to Case Studies: A Christian Articulation of Methodological Naturalism

The vast majority of leading natural philosophers since the late 19th century have largely signed on to the increased "naturalization" of science. This has occurred even though many of the leading pioneers were Christians who maintained an openness to theism. Furthermore, by the time we get to the later 19th century, it became much more common for Christian scientists to call for a clear separation between theology and science as documented by Hedley Brooke and Ron Numbers.[44]

One of Numbers' most salient points is that Christians (whose Christian cre-

[43]John Clement Whitcomb and Henry M. Morris, *The Genesis Flood : The Biblical Record and Its Scientific Implications* (Grand Rapids, MI: Baker Book House, 1961).

[44]John Hedley Brooke, *Science and Religion: Some Historical Perspectives* (Cambridge: Cambridge University Press, 1991). Ron Numbers, "Science without God: Natural Laws and Christian Beliefs," in *When Science and Christianity Meet*, eds. David C. Lindberg and Ronald L. Numbers (Chicago: University of Chicago Press, 2003).

dentials are solid) spoke out prominently in favor of such naturalistic methods. For example, he tracks briefly the reception of the Darwin's *Origin of Species* among Christian scientists. Aside from the arguments for and against Darwin's bold and quite risky hypothesis, the attitudes regarding naturalistic methods in natural history are notable. Numbers observes,

> In his revolutionary *Origin of Species* (1859) Darwin aimed primarily "to overthrow the dogma of separate creations" and extend the domain of natural law throughout the organic world. He succeeded spectacularly—not because of his clever theory of natural selection (which few biologists thought sufficient to account for evolution) nor because of the voluminous evidence of organic development that he presented—but because, as one Christian reader bluntly put it, there was "literally nothing deserving the name of Science to put in its place."[45]

Numbers proceeds to quote William North Rice (1845 – 1928), an active Methodist,

> The great strength of the Darwinian theory . . . lies in its coincidence with the general spirit and tendency of science. It is the aim of science to narrow the domain of the supernatural by bringing all phenomena within the scope of natural laws and secondary causes.[46]

Numbers quotes Asa Gray as an important receiver of the methodological breakthrough of Darwin's theory. Gray explained that "the business of science is with the course of Nature, not with interruptions of it, which must rest on their own special evidence."[47] George Frederick Wright (1838 – 1921), geologist and Congregational minister, accorded with such fundamental principles of science:

> We are to press known secondary causes as far as they will go in explanation of facts. We are not to resort to an unknown (i.e. supernatural) cause for explanation of phenomena till the power of known causes has been exhausted. If we cease to observe this rule, there is an end to all science and all sound sense.[48]

In sum, naturalism appealed to them and a host of other Christians because it served as a reliable means of discovering God's laws. In field after field, the course of science has vindicated the observations of these good Christian men. We now turn briefly to the question of why methodological naturalism works so well in science. We offer three reasons consistent with a Christian worldview: (1) its relative universality; (2) its congruence with the supernatural nature of God; and (3) its congruence with Divine action. We do not have room here to fully expand each of these ideas, but we can begin to sketch out how methodological naturalism and orthodox Christianity need not be at odds with one another.

[45]Numbers, "Science without God: Natural Laws and Christian Beliefs," 279-280.
[46]Ibid., 280.
[47]Ibid., 280.
[48]Ibid., 280.

Alvin Plantinga has acknowledged the wisdom of Pierre Duhem in the latter's famous essay, "Physics of a Believer."[49] Duhem was responding to criticisms by Abel Rey that Duhem had allowed his Catholicism to creep into his physics inappropriately. Duhem responded with a rich reflection upon the relationship between his Catholic faith and his physics. One of his main points is very simple: keep metaphysics out of physics, and thus, keep religious beliefs (themselves dependent upon a certain sort of metaphysics) out of physics. Plantinga cites the following Duhemian insight:

> Now to make physical theories depend on metaphysics is surely not the way to let them enjoy the privilege of universal consent. . . . . If theoretical physics is subordinated to metaphysics, the divisions separating the diverse metaphysical systems will extend into the domain of physics. A physical theory reputed to be satisfactory by the sectarians of one metaphysical school will be rejected by the partisans of another school.[50]

As Plantinga summarizes, this argument for methodological naturalism builds on the intuition that we all—Christian, naturalist, agnostic, and so on—should be able to work at physics and the other sciences together and cooperatively. Therefore we should not employ, in science, views, commitments, and assumptions that it is clear only some of us accept.[51] This means that we cannot presuppose for the purposes of science various received truths of Christian faith (on creation, original sin, free will, and so forth). Duhemian science aims to proceed from premises that are shared universally.

Plantinga concedes that this is a powerful argument to practice Duhemian science or methodological naturalism when such makes sens*e*; that is, in those domains where it has proven to be successful. However, as noted, Plantinga has suggested that some areas of biology might well be fertile ground for Augustinian science and as Plantinga observes, "In the human sciences, however, vast stretches are clearly non-Duhemian; it is in these areas that Augustinian science would be most relevant and important."[52] He goes on to conclude "[t]here is nothing here to suggest that if it ain't Duhemian, it ain't science."[53] When "natural" scientific approaches give answers that seem improbable in light of the assumptions of Christian theology, then the Christian ought to employ what she knows by faith to guide inquiry showing that such "naturalistic" approaches are wrong-headed.

This may sound somewhat innocuous in principle and it may be perfectly sensible in some respects, say, as a description of a broadly intellectual Christian

[49]Pierre Duhem, *The Aim and Structure of Physical Theory*, trans. Philip P. Wiener (Princeton: Princeton University Press, 1906; reprint 1954).
[50]Ibid., 10.
[51]Alvin Plantinga, "Science: Augustinian or Duhemian?," *Faith and Philosophy* 13.3 (1996), 354.
[52]Ibid., 355.
[53]Ibid., 355.

response. However, if it is taken seriously enough to apply in scientific practice, then it would change the culture of science significantly, potentially Balkanizing certain areas of science. In fact, in such a framework, it seems plausible that we would find ourselves having to cordon off certain areas of inquiry that we wish to call "science" but which we readily admit are very likely to fail to garner broad consensus among competent investigators. Competency may well matter less in these "Augustinian" scientific domains than theological and confessional commitment. Though a full argument for the relative universality objection would require an additional paper, it helps us understand why the case for MN science is consistent with a deep Christian commitment.

So, while it may seem attractive to open up the possibility of appeal to Christian wisdom in the human sciences, it has yet to be shown that explicit invocation of Christian, faith-based knowledge proves today, even for Christians, to be a promising research program in human biology, psychology and sociology.[54] In sum, methodologically naturalistic science has come to be a reliable general framework for achieving broad consensus in the various sciences. This universality is an important part of what we have come to expect and value in science.

(2) Naturalization of the Supernatural and the Gap-Naturalization Dilemna

The vitalism of Van Helmont and Stahl was not naturalistic (as we have already discussed). Stahl proposed that anima could not be observed directly, but that its effects on matter could be observed. Those effects included the sustenance of processes (namely life) that could not be explained with the knowledge of the day. In other words, anima filled explanatory gaps within the knowledge of physiological processes. Similarly, Newton's appeal to God as a source of planetary fine-tuning filled an explanatory gap in the stability of the solar system. The appeal of ID proponents to intelligent design as a way to explain the presence of information and non-reducible complexity in the cell seems similar—it attempts to fill an explanatory gap in current evolutionary theory.

Although aspects of the supernatural hypotheses of ID are empirically accessible (as was the hypothesis of anima for Stahl), the main evidence for the hypothesis is always indirect—we can see only the effects of the designer on the physical world, not the designer himself. Furthermore, it is difficult to constrain the designer in a way that might let us study those effects in a controlled way. If the intelligent designer is to remain in the realm of the supernatural—that is, if the designer is to remain unconstrainable—then evidence for his or her existence will be gap-like in nature.

Later vitalistic theories became naturalized fully—the vital force of Liebig was no different than the other forces of nature. Naturalized forces, such as gravity, for

[54]For further discussion of the pitfalls of Augustinian "human" science, see the work of David Diekema, "The Weakness of Metatheory: The Case against a Strong Christian Social Science" (unpublished ms.).

example, are constrainable—we can carry out controlled experiments, such as dropping masses and measuring their rates of descent, to test them. Supernatural forces, in contrast, are not constrainable. The theistic scientist, it seems, is left therefore with the following dilemma that we have named the gap-naturalization dilemma:

a) If the supernatural element within a scientific theory is to remain fully supernatural, then evidence for the existence of that element must necessarily be an argument from gaps in physical explanations (because the supernatural element is not constrainable and subject to experimentation). Arguments from gaps make for a very poor apologetic and have failed miserably because, when the gaps are filled, the supernatural element must necessarily become smaller.

b) If the supernatural element within a scientific theory is to be constrained fully in order to carry out controlled observations and experiments on it, the supernatural element ceases to be supernatural—it simply becomes another force of nature. For the Christian, of course, the naturalization of God is untenable. If God were to become just another physical force, He would cease to be the God of Christian theism.

The theistic scientist is left therefore with a difficult choice: either argue from gaps or naturalize God. Neither option seems attractive from a fully Christian viewpoint. Notice that we are not arguing here that ID inferences are gap-like in nature. We are saying simply that if they are not—if God acts in ways that are constrainable and measurable—then he becomes a naturalized god.

(3) Congruence with Divine Action

Methodological naturalism may work well because it is consonant with a fundamental truth about the physical world and the Creator. It may be that God created and sustains the world through regular law-like actions amenable to methodological naturalism. Why should we believe this? Firstly because the success of methodological naturalism suggests that it might be so. However, as Christians, we may find some support for this idea from our own experiences of God's actions and through Scripture.

Let us assume that natural law or natural processes are simply the way that God normally acts. By this definition, scientific laws and theories are simply descriptions of the way that God normally acts. Supernatural acts are those acts in which God chooses, for whatever reason, to act differently. Supernatural acts would have no scientific explanation because they are not repeatable—they would leave gaps in the causal order. Under these definitions, the difference between supernatural and natural are quantitative not qualitative differences—in both cases, God is acting.

The success of methodological naturalism may be because God overwhelmingly favors acting through natural law rather than against it. We may pray for rain and rain may come, but meteorologists can always trace back the developments in storms and explain their movements in ways consistent with natural law.

We may pray to make it to our next class on time, and we may actually make it, but we are not usually transported there through space in an instant. Under most circumstances, God answers our prayers in ways consistent with natural law. We are not arguing that God could not, if He wanted to, answer our prayers supernaturally. We are simply stating that, in most instances, He does not.

It also seems relatively clear that God has worked through natural law throughout Biblical history. Perhaps more striking than the presence of miracles in the Bible is their absence. Beginning in Genesis, God did not simply make the entire universe, already filled with plants, animals, and 6.7 billion people. Rather, He used natural law to bring the earth to where it is today. Genesis tells us that God brought forth vegetation from the earth; that is, it grew in accordance with natural law. God did not create several hundred thousand of each kind of animal, but rather created some of each and told them to multiply via natural processes. Likewise, He did not fill the earth with 5 billion people, but rather created two and instructed them to multiply, again through natural processes. If we comb through the Old Testament, we see example after example of how God worked through natural processes to accomplish his ends. In the Genesis Flood, God could have simply willed that every person, except Noah and his family, cease to exist. But He did not do that; rather, He used a natural process—rain—to achieve his purposes. Israel's enemies did not simply fall instantaneously, but rather, through battles and wars, most of them consistent with natural law, Israel prevailed. We note that Israel still ascribed their victories to God's power; that is, they could plainly see that God worked through natural law—unlike some modern day Intelligent Design theorists.

The Psalms tell of God's delight in and control over nature. Psalm 19 tells how nature declares the work of His hands. Psalm 24 tells us the earth is the Lord's. Psalm 46 tells us that we need not fear the earth, since God is our refuge, implying that God is in control of the earth, even when the mountains quake and the waters roar. In Psalm 48, God uses the wind to break the ships of Tarshish. Again, why did God use a natural process, the wind, instead of simply causing the ships of Tarshish to evaporate? God seems to have a strong preference for using the system He set up and maintains.

In the New Testament, certainly we see Jesus performing miracles that would not be explainable by natural law. But His miracles are not wholly opposed to natural law. Rather, they demonstrate his complete control of and harmony with natural law. Even the virgin birth, certainly not a natural event, was nonetheless indicative of God's preference for the natural process; that is, Jesus did not simply appear as a full grown adult, but rather was born in the usual way and developed from an embryo into an infant, toddler, child and eventually an adult.

C. S. Lewis puts it this way:

> Miracles, if they occur, must, like all events, be revelations of the total harmony of all that exists. Nothing arbitrary, nothing simply "stuck on" and left unreconciled with the texture of total reality, can be admitted. By definition, miracles must of course interrupt the usual course

of Nature; but if they are real they must, in the very act of so doing, assert all the more unity and self-consistency of total reality at some deeper level. *They will not be like unmetrical lumps of prose breaking the unity of a poem.*[55]

Intelligent Design theorists and theistic scientists are asking us to accept unmetrical lumps when such lumps are not even in the Bible's recording of miracles. God does not constantly turn natural law on its head to achieve His purposes. It is instructive to note, as Lewis points out, that Jesus never performed arbitrary miracles: He did not turn rocks into bread; He never caused rabbits to appear out of hats; and he never made Pharisees disappear in puffs of smoke; it was not His way.

The God portrayed in Scripture, as well as the one we have experienced, seems to be One that overwhelmingly prefers to work through natural law rather than against it. Is this surprising? We may be more surprised by the opposite situation. Why would God go against the system He created and maintains? Did He overlook something which now needs adjustment to accomplish His ends? Did He change his mind as He went along and therefore have to do things in a different manner?

Conclusion

Science succeeds best when it sticks to the kinds of claims that can be adjudicated by observation and experiment, and be framed in a precise conceptual vocabulary. In a global context, methodological naturalism allows, even forces, science to do this. This does not mean it must always be this way, but the many successes of science operating in this framework warrant "business as usual" because such business has been good. Solving the origins of life, or all transitions in life, or the questions of cosmology, by a sky-hook to a designer might be the best "ultimate" explanation. But there are many steps to take within the framework of methodological naturalism before we should ask science to go beyond it.

While Christians have every reason to believe, given the content of our faith, that nature as a whole and even detailed kinds within nature are designed by God, this does not mean—as asserted by the Intelligent Design movement—that such beliefs will be known clearly through scientific inquiry. To rely on science in this way marginalizes not only the Christian church, but also other disciplines such as theology and philosophy from their roles in establishing knowledge. Further, if Christians already know these basic truths about God's creative activity, then importing them into science "officially" will not do much to warrant them further. The only reason to pursue a path that violates methodological naturalism would be if doing so provided a clearly superior explanatory account of specific questions about the history of life, specific living systems, or problems in understanding

[55]C. S. Lewis, *Miracles; a Preliminary Study* (New York: Macmillan Co., 1947), 97 (emphasis ours).

human nature. To date, ID has not succeeded in achieving any of this. Until a much sharper outline emerges as to how this will go in detail, there is no reason to suspend methodological naturalism within what we call "science."[56]

[56]We wish to thank the Templeton Foundation and the Council for Christian Colleges and Universities for their generous support, allowing the authors to participate in the John Templeton-Oxford Seminars on Science and Christianity. Without that support this paper would not have been written. Thanks also to Steve Layman, Ken Himma, Phil Goggans, Carl Gillett, Paul Pardie, and John Roche for reading all or parts of drafts. Their guidance helped improve the essay tremendously. Finally, we wish to thank the two anonymous reviewers for *CSR* whose comments also improved the argument considerably.