What sort of value is order in science?

Eric C. Martin
UC-San Diego
Department of Philosophy
Program in Science Studies

A*bstract*: The traditions of mechanistic philosophy and natural theology have jointly contributed to a predominating image of God as a divine engineer. I historicize the ways in which God's creative practices have been associated with order, efficiency, and standardization, while nature – at least by the 19th century – was associated with contrasting qualities of plurality, diversity, and abundance. Darwin himself, as well as later interpreters of evolutionary theory, have contributed to these important developments. Historians and philosophers of science have recently challenged the erstwhile view that science is uncovering universal laws that order nature. New metaphysical portraits have emerged from this work, emphasizing the rich variety of entities, activities, and causal relations in our rather disordered and "dappled" world. These insights provide fresh opportunities to evaluate the attributes of the creator of such a world. This paper explores a view of a God who fashions diverse constituents of the world for their own sake – rather more like an artist than an engineer. This view challenges a pervasive value in science that I categorize and discuss as a "metaphysical" value of order.

"[The Universe] is like a rare clock… where all things are so skilfully contrived, that the engine being once set a-moving, all things proceed according to the artificer's first design, and the motions... do not require the particular interposing of the artificer, or any intelligent agent employed by him, but perform their functions upon particular occasions, by virtue of the general and primitive contrivance of the whole engine."
Robert Boyle

"God *must* be an engineer, because nature *is* a machine."
Carl Becker, paraphrasing Hume's Cleanthes

1. Introduction

In this essay I aim to challenge the belief that if God has made the world, then such a creation must be well ordered in a way that befits a dominant image of divine rationality and creative efficiency under universal laws of nature. While I think there are

compelling arguments that nature is not ordered as imagined by this old standard, I try to reconcile this disordered conception of nature with a creative and benevolent God.

In what follows I suggest that the scientific project of uncovering nature's unity and ultimate order are closely related to theological views about how God must have created the world. Both philosophy of science and theology are relevant to this topic. My discussion of a scientific search for natural order will be framed, in turn, as both an explicit philosophical commitment – one that finds an important source in early modern metaphysics – and also as an implicit *value* often held by scientists today. My discussion of God's creative capacities departs from some standard representations of the Deity, and may be incompatible with some religious tenets, but, as I hope to show, remains compatible with other Judeo-Christian commitments. I explore a view of God as a creator who fashions quite diverse constituents of the world for their own sake, and in a manner more akin to an artist than an engineer. The artistic process to which I appeal emphasizes creativity, novelty, and heterogeneity over uniformity, efficiency, and universality. This artistic conception of God is something of a departure from an influential line of thought linking God's creative process with modern, mathematically-oriented engineering. Though the engineering view has been prominent in many areas of discourse, from physics to theology, I will be concerned with these issues especially as they have related to biological theory. Briefly stated, the engineering view supposes that God rationally (in a way familiar to the rational calculations of modern engineers) constructs elegant and efficient systems of biological complexity which operate in accord with the fundamental laws and are immediately, perfectly, and finally suited to their various stations in the world.

This engineering view of God figures prominently in the history of natural theology, that intellectual tradition which looks to the world to teach us about the nature of its creator. Seventeenth and eighteenth century mechanistic philosophy provided an influential metaphysical representation of the world, construing nature as so much machinery, ultimately subject to immutable and universal laws. For many natural philosophers of the day, the rationality of nature became nearly an observable phenomenon – empirical observations were couched as elements of an orderly, rule-bound world. That representation of the world then reflected on the characteristics of its

creator. The structure and function found in various organisms, for example, evinced the ingenuity of the designer who made them so well adapted to their respective environments. God became the divine engineer, arguably quite remote from the unwinding of his creation. Advocates of intelligent design, one branch of our latter-day inheritors of natural theology, continue to offer design arguments for the existence of God. Such thinkers, like their forebears, find within nature purposive design, rational order, and God's engineering handiwork.[1]

Charles Darwin's comprehensive case studies and sustained arguments persuaded the biological community of the explanatory relevance of natural selection. The central role of chance variation, and the fact that species in similar environments could diverge onto distinct evolutionary paths, all testified against the claims of special creationists. On Darwin's view, to continue insisting that an omnipotent God was behind these disparate and unpredictable evolutionary phenomena could only lead to a God of fractured intents and inconsistent action – hardly a God worth believing in: "Some authors maintain that organic beings have been formed in many ways for the sake of mere variety, almost like toys in a shop, but such a view of nature is incredible."[2] Any God that made a world such as we have discovered could only be an irrational one, given certain norms of rationality. For Darwin, if God existed at all, then he was perforce a God who instantiated a small number of elegant laws, whose action could produce the spectrum of biological phenomena we observe.[3]

The pervasive mechanistic philosophy found throughout the enlightenment and scientific revolution –one to which Darwin was heir[4] – altered earlier views of God. No longer primarily a revealed God, God became that being who created the law-governed world that natural philosophers described. And what they described was a sparsely constituted world whose elements all obeyed a few fundamental laws; something like this remains a prominent metaphysical view in contemporary philosophy.[5]

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[1] A recent example is Behe 2007. A critical review is Sean Carroll, 2007, appropriately titled: "God as Genetic Engineer".
[2] Darwin 1872. p. 172.
[3] Lewens 2007, p. 124.
[4] Mechanistic philosophy was one of several philosophies of nature to which Darwin was exposed, which included the German Romantic tradition: see Richards 2002.
[5] See, e.g., Swinburne 1979.

And yet if our metaphysics is at least minimally informed by science, then one would expect some changes in our metaphysics, given scientific progress and greater awareness of scientific methods. Compared with traditional enlightenment views, our contemporary representations of the natural world may reflect very differently on God's actions and characteristics. Alternative metaphysical pictures of the natural world may very well call for alternative images of God. I hope to re-orient some ideas about God's creative process, and resulting creation, in a way that better fits with recent insights from the field of history and philosophy of science. The work to which I refer arises from detailed case studies of scientific practice, and has offered new ways of thinking about how science actually works – ways that challenge the erstwhile view that science describes an orderly and rule-bound world. Such work articulates the apparent disunity of science, but also provides a metaphysical account for that disunity.[6] These studies emphasize the world's "patchiness" rather than regular conformity to universal laws: a pluralism about natural laws as well as the entities (and their attendant capacities) that populate our world. If this is a world that God has fashioned, then it is a far richer and more variegated creation than is often credited to him. Given these insights, Darwin's claim of biological creation akin to "toys in a shop" is not as incredible as it may have first appeared. I hope to render more plausible a possibility that Darwin may have found unlikely: not that God specially created the biological world, but that his creation could evince the degree of plurality we seem to witness in the biological world.

In what follows I suppose that even if the findings of Darwin and ensuing thinkers have in fact made the engineering conception of God a dubious one (§2), that such a view does not exhaust possible conceptions of God (§3), and that alternative conceptions at our disposal may actually accord better with independently preferable metaphysics (§4). I then discuss how these ideas about order are actually instantiated in scientific practice, and to that end I conclude with a discussion of order as a distinct kind of value in science (§5). Scientists' expectations of ultimate order is typically not a consequence of philosophizing, but a certain type of value that rarely is subject to argument or empirical warrant.

[6] Dupre 1993, Cartwright 1999.

There has been little challenge so far to the assumption that if nature is a product of God, then it must reflect divine order in its regimentation under universal laws of nature. I suggest that relaxing such assumptions is not only a theological possibility, but is best in accord with what natural sciences teach us about the world.

2. The engineering God

How did the God of Abraham and Isaac become so readily identified as an engineer? One crucial part of the answer is found in the unfolding of mechanistic philosophy, the result of a long process in which theology and natural philosophy informed one another. Nature was construed as well ordered, reflecting God's own perfection. Conversely, in the tradition of natural theology, the order of nature was evidence for God's existence, wisdom, and beneficence. Not just any God emerged from this early modern philosophy: it was a God with particular qualities similar to those of an engineer.

The traditions of natural law and of the world as machine arose somewhat independently, but reached full expression in the early modern period, when they combined to form an influential image of nature. The 16th and 17th centuries witnessed important changes in who was talking about theology, what theology meant, and to whom it was directed. This is the period that gave rise to what Amos Funkenstein called "secular theology": a theology oriented toward the created world.[7] Its source was not just from clergy but from laymen, and it was increasingly directed at an audience outside the church. At the same time, there was an erosion of professional boundaries in the university. Where separate disciplines were fundamental to the peripatetic programs of Aristotelian and Scholastic traditions, this period of "secular theology" gave birth to the ideal of a system of all knowledge founded on one method. Theology could hardly be excluded from this new system, and it is a period in which "God ceased to be the monopoly of the theologians." God was part of a new, rather more worldly discourse.

This period, when philosophy, theology and the nascent sciences were so intimately connected, appears to be a crucial moment in shaping the history of natural theology. It also gave rise to influential ideas about laws of nature. God's omnipotence became closely linked with laws of nature, as the ancient dichotomy between *nomos* and *phusis* weakened and eventually collapsed.

[7] Funkenstein 1986.

In 1543, Copernicus spoke of the "machine of the world founded by the best and most regular artificer."[8] But according to historian Edgar Zilsel neither Copernicus nor Galileo used the term "natural law." Even Kepler's famous "laws" were typically dubbed so only in retrospect; in his astronomical texts Kepler often referred to them as "ratios" or "theorems." But in a letter to Fabricius from May 1605 Kepler reported that he has treated the irregularities of the planetary movement "until they were at last accommodated to the laws of nature." Presumably those laws were the same things he described in *Harmonices Mundi* (1619) as God's having ordered the universe according to the principle of "geometrical beauty." Here we have a mathematical aesthetic under which irregularities could be accounted for by appeal to ultimate regularities. The scientific task was to reveal the mathematical order of the world, describing its beauty and thereby praising God as its founder.

Descartes' *Discourse on Method* (1637) clearly declared that he had found "laws which God has put into nature", though he didn't specify precisely what the laws are. He stated that "the rules (règles) of nature are identical with the rules of mechanics."[9] In his 1644 *Principles of Philosophy* Descartes urged that it is due to the immutability of God that "some rules or laws of nature which are the causes… of the various motions can be understood." Moreover, those laws cover *everything*: "Thanks to these laws of nature, matter successively takes on all the forms of which it is capable."[10]

Spinoza appropriated many of Descartes' ideas about laws and added to them an insistence of their necessity. Over and again Spinoza emphasized that "everything is determined by the universal laws of nature."[11] Spinoza furthermore extended these universal laws, (now in a panentheistic, rather than theistic, context) to cover human mental phenomena as well.

The conviction that nature is largely – even completely – ordered found powerful expression in the works of Leibniz as well. In a letter to Bourget, Leibniz links this prevalence of order to a prevalence of intelligibility: "To be possible, it is enough to be

[8] De Revolutionibus, preface to Paul III. Cited in Zilsel 1942 p. 261.
[9] Adam-Tannery VI 54 1.26.f
[10] *Principles of Philosophy*, Part III, 47.
[11] *Tractatus Theologico-Politicus* cap. 4 Opera II 134.

intelligible; but for existence there must be a prevalence of intelligibility or order."[12] Reason is thus immanent in all created things. As Louis Couturat put it, "reality is completely penetrable by reason, because it is penetrated with reason."[13] As Leibniz saw it, nature is "shot through" with order. Moreover, the ability of humans to rationally apprehend that order is what contributes to human happiness, the moral perfection of the world, and is all a part of God's creation of the best possible world.[14] For Leibniz, God's choice of *simple* laws of nature was linked with God's creation of the maximum number of things, which in turn was linked with the greatest metaphysical goodness. In a 1679 letter to Malebranche, Leibniz writes:

> We must also say that God makes as many things as possible, and that what obliges him to seek simple laws is precisely the necessity to find place for as many things as can be put together; if he made use of other laws, it would be like trying to make a building with round stones, which makes us lose more space than they occupy.[15]

Rather than being at odds with a maximal number of things, simple laws are actually the *means* to such a maximum.

Newton's 1687 *Principia Mathematica* contains law terminology from its preface onwards, and made the term a familiar component of the scientific vocabulary. Around the time that Euler was codifying Newton's laws into Newtonian mechanics, he along with Maupertuis enlisted the "law of Least Action" to argue that God always acted in the most economical manner possible. Maupertuis believed that if we could understand all variation as a product of a small number of natural laws, then "*the spectacle of the universe becomes so much the grander, so much more beautiful, and more worthy of its Author."*[16] Maupertuis' mechanistic theories were not limited to terrestrial mechanics: in an odd publication called *The Earthly Venus*, and amidst semi-pornographic praise for the manifold pleasures of sex, he advanced a theory of animal generation, making attractive forces between particles within "seminal seeds" the motive force in the creation of new offspring.

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[12] Rutherford 1995, 64 f. 15
[13] Rutherford 1995, p. 50.
[14] Rutherford 1995, chp. 3
[15] Gerhardt 1960, I p. 331
[16] Essai de cosmologie, 1

This schematic outline serves only to point out the manifold connections being forged by "secular theologians" between God's actions, a mechanical world, and the mathematical, orderly rules that govern such a machine. These trends extended beyond physics. An engineering view of God is further exemplified in design arguments. A canonical statement is found in Archbishop William Paley's *Natural Theology*, published in 1802. If we chance to come upon a watch in the woods, so the argument goes, then the best explanation for the existence of such complex machinery is that it had been fashioned by a person and was made for precisely the function it is carrying out. This image must have resonated with natural philosophers who had been in the business of describing the world as like a clock, as in Boyle's epigraph. Paley was required reading in many British universities in the 19th century, and he had a great pupil and admirer in Charles Darwin, who wrote: "The logic of [Paley's treatises] gave me as much delight as did Euclid. The careful study of these works… was the only part of the Academical Course which, as I then felt and as I still believe, was of the least use to me in the education of my mind… I was charmed and convinced by the long line of argumentation."[17]

Nevertheless, Darwin's own work soon challenged the credibility of such design arguments (or special creationism). His biogeographical research showed how his principle of natural selection could lead to the mutability of species and to the morphological patterns we observe. The fossil record, geographical relations between related species, and structural homologies all provided evidence for an evolutionary theory, while design arguments explain only the existence of some order or structure, with little detail beyond that. These arguments for the centrality of natural selection, and the poverty of special creationism, have been so decisive that today the pair of theories is sometimes thought to illustrate a demarcation between science and non-science.[18]

I will emphasize one line of thought from Darwin's writing that is especially relevant to my topic. Darwin's work on orchid morphology, while hardly his most famous case study, proved surprisingly central to his own thinking on chance variation

[17] Darwin 1969, p. 59.
[18] Pennock 2006.

and on the theological ramifications of his theory.[19] His friend and supporter Asa Gray approvingly cited this work as "a flank attack on the enemy" – that being the special creationists. To understand why this work constituted a strategic attack, and why Darwin relied so often on the insights he drew from his studies of orchids, we need to appreciate the creationist views to which Darwin was responding. Like all teleologists, these creationists explained organic form in terms of its usefulness. The Protestant creationists with whom Darwin was in contact reasoned that God, in his wisdom and foresight, had equipped each species with just the right traits required for its perpetuation. Moreover, similarities and differences in form ought to reflect similarities and differences in use. For example, the shape and constitution of hands makes them good for grasping, while the shape and constitution of feet makes them good for walking. So differences in form are to be understood in terms of differences in use.

But Darwin found something else going on in orchids. When observing and explaining the various morphological structures, he appealed not to distinct environmental features, as he would to explain diverging finch species on the Galapagos, but only to chance variation. Chance variations are ultimately caused by the environment, but in such a complex way as to be in-principle unpredictable, and they are not necessarily adaptive. The contingent outcomes of natural selection acting on chance variations lead to chance evolutionary divergences. Darwin noted that all the various floral structures were serving the same purpose: to inhibit self-fertilization in these hermaphroditic plants and to facilitate cross-pollination by insects. Again, he did not explain the different floral structures in terms of different pollinators or any other environmental differences. Even in the same environment, species could diverge, and different forms can be explained by appeal to the same functions. "In my examination of Orchids, hardly any fact has struck me so much as the endless diversities of structure, - the prodigality of resources, - for gaining the very same end."[20]

Hence, in orchids and many other families besides, contrary to the creationists, *different forms serve the very same use*. This insight was incorporated into later versions of *Origin of Species*. "The common rule throughout nature is infinite diversity of

[19] This section relies on Beatty 2006 and references therein.
[20] Darwin 1988.

structure for gaining the same end."[21] Natural selection could both produce and maintain variety, but the theistic story of special creationism could not. At best, Darwin's interlocutors could argue that the Creator had caused these forms to exist "for the sake of mere variety," but for Darwin, at least, "such a view of nature is incredible." What he means here by incredible, presumably, is irrational. Darwin thought that the "unprincipled" diversity of form, all for the same end, undermined expectations of God's role in organic creation. The key here is an assumption that Darwin held in common with his creationist interlocutors: rationality demands that a single function is designed in a single way. Presumably that is the *best* design; at the very least it is a standard design. It is the assumption about *uniformity* to which I draw attention. Diversity and abundance were becoming characteristics attributed to nature, while standardization and uniformity remained as they had been associated with God.

God, *qua* engineer, was expected to be frugal, but nature, apparently, was prodigal. Such tensions were not only recognized by Darwin, but were spread and elaborated upon by his students. That particular disconnect between the attributes of God and nature was an important source of personal religious uncertainty for one of Darwin's young protégés, George Romanes. Romanes was a founder of sorts for evolutionary psychology and an early advocate of Darwinism. His popular lectures initially expressed his religious faith, but over time that faith vacillated and was sometimes absent. In a posthumously published essay called "A Candid Examination of Theism," Romanes argues that no appeal to God can be made based on any similarity between human and divine intellect, since "if a man has occasion to devise any artificial appliance, he does so with the least possible cost of labour to himself and with the least possible expenditure of material. Yet it is obvious that in nature no such economic considerations obtain."[22] Insofar as claims to divine intelligence are rooted in analogy to human intelligence, Romanes found this description of nature quite troubling for the theist. He accused natural theologians of cherry-picking the few instances of nature's economy, while ignoring the far more pervasive instances of nature's prodigality. Romanes found in nature "reckless waste",

[21] Darwin 1872, p. 283.
[22] Romanes 1878.

which ought to give pause to the natural theologian's arguments based on efficiency, order, or economy.

Such worries about attributing the "waste" of natural selection to God's intentional actions continue to echo today. For example, Francisco Ayala argues that natural selection is a boon to the theist insofar as it removes responsibility of biological inefficiencies from God, placing that responsibility on nature instead. Ayala argues that the natural world is not "intelligently" designed, but "incompetently" designed, and that the theist ought not to attribute the manifold biological "blunders" to the Deity. His worry about the nature of biological creation is telling: "A human engineer would have done better."[23]

Philip Kitcher notes that when it comes to God's responsibility for his creation, increased distance doesn't necessarily help his case. God bears responsibility for biological creation whether he looks down on the "unwinding" from a removed perch or is individually engaged in each act of creation. The problem remains the same: God's ostensible creation certainly doesn't seem to measure up to his engineering credentials. When Kitcher surveys biological evolution, he notes that it "seems breathtakingly wasteful and inefficient."[24] He writes that "whimsy" would be the most generous description of God's creativity, but all the same, the world of biology is so imperfect that it is difficult for Kitcher to even imagine a "kindly" God looking down on this mess.

But how did such these scholars arrive at the point where it seems natural to link ideals like *efficiency* with such theologically central notions as God's *beneficence*? Is not God's goodness, if it exists, compatible with rather less efficient creative acts? If that is possible, then it seems worth analyzing both the source and justification of these claims about efficiency. In what follows, I hope to show that that the recognition of such "unprincipled" diversity need not rule out the possibility of understanding the organic world as a product of God's.

3. Ways of creating

[23] Ayala 2007, p. 155
[24] Kitcher 2007, p. 124

In light of his biological studies, Darwin thought that even the requisite kind of special creationism to which God would have needed resort was "beneath the dignity of him, who is supposed to have said let there be light & there was light--"[25] The need to intervene individually on each and every variation between barnacle species may have been unseemly to Darwin. He notes also the "astonishing waste of pollen by our fir trees"[26] among the reasons that his theory of natural selection out-competes special creationism – such "waste" is acceptably credited to nature, but surely not to the Almighty himself. These quotes highlight an *aesthetic* dimension to Darwin's thinking on the issue: his God was sufficiently austere and removed so as to be *above* very specific acts of creation – acts which could only sully, it seems, God's sterling reputation. This God did not deign to get his hands dirty, nor could he have gotten the proportions wrong. The creative acts of Darwin's God seem relegated to Platonic ideals of perfection, simplicity, and beauty.

I would like here to bring attention to the *praxis* of creation. The generic category of "creation" collapses together many different ways of creating, and such methods require attention if we are to be analyzing God's creative capacities. Without unduly simplifying processes which certainly admit many degrees of variation, I will delineate two distinctive types of creation, labeling them engineering and artistic.

Engineering is often characterized by means-end reasoning, standardization of supplies and construction methods, uniformity, moderate redundancy, and the search for ever more efficient building techniques.

Artistic creation, on the other hand, often exhibits quite distinct methods. Creativity, novelty, and heterogeneity take precedence. Hyper-redundancy and inefficiency may abound. Artistic processes often sublimate the utilitarian ideals of engineering to their own aesthetic purposes.

It is possible to articulate a theistic evolutionism along the lines of this latter, artistic process. God creates a patchwork of biological phenomena, by no means perfectly coordinated with each other or conforming to a universal order. A host of emergent entities and properties are only locally and contingently governed, in ways that do not

[25] From *Notebook D*, in Barrett et al. 1987.
[26] Darwin, 2003. p. 472.

neatly mesh across different domains. Even single functional uses may find a host of morphological expressions to achieve those ends.

If the above view is a possibility, then why has there been such a tendency to assert or to assume that God must operate according to the maxims of engineering? There is a plausible historical case to be made that those are just the ideals that arise from traditional mechanistic philosophy: these ideals, which have emerged primarily from the study of terrestrial mechanics and then physics more generally, remain influential today. When the world was a machine, God was its designer – but a particular *sort* of designer at that: one whose insight and rationality accorded with the nature of his project and the extant cultural expectations of the day. It is clear that a host of social, political, and other theological views informed principles as broad as the very nature of God, but it seems that natural philosophy articulated and reinforced those tendencies in particular ways. Because the world was a machine, God must have been its engineer.

Such "artistic" evolutionism is not compatible with some traditions of religious belief. If God uses natural selection to bring about his own variegated works of art, that might rule out literal creation narratives; static members of species; ideal forms from which other members merely diverge; final or specific stations in the world; and much less "perfection," at least when that notion is associated with an organism's final suitability or maximally adapted fit with its environment. Instead, variation permits excess and inefficiency for sake of – what some would argue is – beauty. But this would be a beauty consisting in richness, difference, and abundance, rather than sparsity, uniformity, and order.

While this theistic evolutionism is at odds with some religious thought, it may also resonate with other Christian traditions. In particular, some medieval scholastics developed views of God as *artifex* – as one involved with craft or artistic productions. In the 20th century, Catholic philosophers Gerald Vann and Jacques Maritain articulated both a philosophy of human artistic production and of God's artistic processes, the latter involving "superabundant overflow," and multiple *im*perfections that reflect God's "perfect fruitfulness."[27] Maritain writes: "Pondering the art of activity peculiar to the *artifex*,… [the Doctors of the Middle Ages] pondered the activity which our Lord chose

[27] Cited in Nichols 1997, p. 131

to exercise throughout His hidden life; they pondered also, in a way, the activity of the Father; for they knew that *the virtue of art is to be predicated peculiarly of God*, like Goodness and Justice…"[28] Maritain would also say that human artistic creativity is analogous to divine creative activity: human art is "the highest natural resemblance to God's activity."[29] These old traditions call for renewed attention, but they demonstrate at least some history of thinking about God's work as artistic creativity, where the product has an intrinsic worth or value, much like a work of art, and unlike most machines.

4. Dappled metaphysics

I have been gesturing toward "artistic" representations of biological phenomena in which overarching laws of nature are few and far between, and in which universality more generally does not figure prominently. Indeed, biology has long been criticized due to its failure to live up to the expectations concomitant with being a "real science" – namely, to discover exceptionless regularities. If this is in fact a shortcoming, then maybe biology does not produce certified knowledge claims after all. Much more plausibly, the life sciences provide perfectly good knowledge claims, even without appeal to laws of nature. But perhaps there is nothing special about the "messy" or "complex" sciences that absolves them from the fundamental laws that are supposed to be governing the world of physics. Perhaps it is not a failing of the "special" sciences to abide by a philosophy so rooted in laws of nature; maybe the shortcoming is within that philosophy itself.

In recent years, several historians and philosophers of science have been developing new accounts of how science works and of the world described by science. Their work shares in common a reaction against the received view of laws as exceptionless regularities, and thus calls into question central aspects of a scientific world-view that have enjoyed a high status for several centuries. To briefly mention just a few of these results, such research has suggested that laws are historically contingent and not temporally universal,[30] that laws hold only relative to models,[31] that many laws are causal

[28] Maritain 1962, p. 20-21.
[29] Maritain *Art and Faith*, p. 89
[30] Beatty 1995.
[31] Van Fraassen 1989.

principles that do not describe exceptionless or regular behavior,[32] that laws are pragmatic aids to practice,[33] and that nature is governed by powers, capacities, and tendencies rather than laws.[34]

I will provide slightly more detail for one example of work within this vein of thought, and while my sketch will fail to do justice to the philosophical nuance, I hope it will provide a better perspective from which to appreciate the distinctiveness of one emerging metaphysical framework. In her 1999 book *The Dappled World* and elsewhere, Nancy Cartwright has developed a pluralistic and "anti-fundamentalist" philosophy about laws of nature. According to Cartwright, laws hold only in carefully structured experimental environments, but outside of such "nomological machines," regularities are hard to come by, and laws are, strictly speaking, false. To invoke an example of Otto Neurath's, if you drop a banknote from the steeple of a Viennese cathedral onto the square below, the bill will not follow the law F = ma. It will instead float aimlessly to the ground somewhere below, buffeted by the wind, influenced by the air resistance, etc. It is not that laws never obtain, but in order to obtain they require special circumstances, such as a more compact mass within a vacuum. To insist that the same laws are always at work, in all circumstances, is more an article of faith than empirical generalization, and Cartwright labels such faith "fundamentalism." The usual response, that Newton's second law describes a true vector *component* of the multiple forces acting on the falling object, invokes intrinsically unmeasurable features of the world. A properly empiricist account does better to start with the basics, and it seems that *causes* are as central to scientific practice and understanding as are anything.

In Cartwright's story, Newton's laws do tell us something about the world, but they are not empirically testable claims on their own. Instead, they are claims about abstract capacities – about the nature of mechanical motions themselves. To the extent that laws of nature obtain at all, they do only in virtue of capacities, which are metaphysically basic, and are in fact much like Aristotelian natures. What Newton's gravitational law says is that it is within the nature of masses to attract one another. In order to test particular systems, though, we need specific interpretive models, which we have for

[32] Steel 2007.
[33] Mitchell 1997.
[34] Bird 2005, Ellis 2002.

falling masses in vacuums, but lack for falling banknotes. Moreover, such interpretive models are not universally applicable – they have a finite range of application. Cartwright argues, for example, that the BCS model of superconductivity has built-in limits to the range of phenomena it covers,[35] again calling into doubt the fundamentalist's faith that laws are always and everywhere at work.

The resulting view has been called "metaphysical nomological pluralism." Various laws do not all amount (or reduce) to a single, grand, unified "theory of everything." Rather, Cartwright's "dappled" world is "rich in different things, with different natures, behaving in different ways."[36]

The God of such a dappled world might resemble the God described above – prone to create a motley artistic creation, not a supremely well-engineered machine composed of a few uniform parts. Parts of the world work differently under different contexts. Furthermore, there is no license to link the rules governing these various patches into the hierarchically-arranged "system" (with human and social sciences ultimately reducing to physical sciences) supposed in many positivists' doctrine of the unity of science.

I first noted, through the eyes of Darwin and Kitcher, that the biological realm is replete with instances of variety, excess, and inefficiency. Science may very plausibly describe a rather untidy world, and not an exquisitely crafted, finely tuned machine ticking along to the beat of the fundamental law(s). A "dappled" view of nature may be the one that is best supported through our current understanding of science. If there is any connection to be made between nature and God's character, then this paper supposes we need new ways of thinking about God, in particular his creative attributes. The artistic conception outlined above is distinct from other ways of thinking about the deity, and is worth exploring further.

5. Order as a value in science

Insofar as the commitment to order is largely based on arguments about what science finds, critiquing the philosophy of order involves also identifying and critiquing its role in scientific practice. Thus far, I have been discussing the expectation of God's orderly engineering methods as a philosophical or theological stance or assumption. Order is a

[35] Cartwright 1999, chapter 8.
[36] Cartwright 1999, p. 1.

theological value rooted in particular conceptions of God and how he must create. Leibniz's construal of a particular kind of world, for example, designed to evince God's ultimate goodness, was a masterful work of metaphysics. Yet I want my account to incorporate not just the disputes of philosophers, but also the aims and practices of current scientists, for whom the discovery of order still serves as a kind of ideal. Contemporary scientists are quite far removed from their roots in natural philosophy, and for them the conviction that nature is thoroughly amenable to reason, or that they are in the business of discovering the world's ultimate order, is not a considered metaphysical declaration. It is a much looser commitment to order that resides in the unarticulated hopes and ideals of many modern scientific ideologies. But what kind of role does it play in scientific practice, where scientists very rarely invoke God or the history of philosophy? I think it is reasonable to construe the search for order as a particular kind of value operative in science.

There is by now a robust philosophical literature on the topic of values in science, where an extensive taxonomy of values has been developed as a means to analyze scientific practice and knowledge.[37] Also, it is now widely recognized, contrary to many early-20th century depictions of science as an essentially value-free enterprise, that science is frequently subject to a range of epistemic, social, and pragmatic values. Such values not only direct the topics of scientific inquiry, but figure into the evaluation of evidence and hypotheses themselves. I would like to consider order as a particular kind of value in scientific practice, which might be dubbed a metaphysical value. It is metaphysical because it is not just a condition on how some *theory* works or explains, but is primarily about the *world* itself. Whereas predictive accuracy is a typical epistemic value, order is a metaphysical value. It functions as a meta-standard or meta-value that helps to identify what counts as order, including what sorts of phenomena are paradigmatically orderly ones and what sort of explanations are paradigmatically revealing of nature's order.[38]

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[37] For one recent example among many, see Kincaid et al. 2007.

[38] The view I have been articulating is that natural sciences have led to a breakdown in one important ideal of order based on natural law, encouraging instead the adoption of a *disordered* metaphysics. Against my position, it could be argued that science is *necessarily* in the business of finding and creating order, and that particular *standards* or *ideals* of order simply change over

Often, when such metaphysical views are discussed at all in the context of scientific practice, they are lumped under the umbrella term, "background assumptions" or "auxiliary hypotheses." These are useful categories for discussing unquestioned beliefs that inform the assessment of evidence, but they are too broad for discussing the different elements that may be part of that set. For example, the common statistical assumption that some given population is normally distributed seems to be a different sort of belief than a desire that a generalization exhibit universal scope and reflect the underlying efficiency of nature. The latter value needs to be identified and explicated if it is to be criticized. Recognizing it as a metaphysical value draws attention both to its links with a history of philosophy and theology, and to its ability to implicitly structure scientific inquiry by serving as a standard-bearer for acceptable theories and explanations.

The significance of disorder is gaining currency among scientists; the idea that there is something amiss in the ideal of ultimate unity under fundamental laws is beginning to make a broad impact in public discussions of science. To take just one example, a recent discussion article in U.S. mass media written by theoretical physicist Marcelo Gleiser admitted that physics has not lived up to a certain ideal of finding ultimate unity or ultimate aesthetic beauty. The perfection that physics had strived to discover simply hadn't panned out, and the author advocates abandoning the ideal of perfection and unity that props up superstring theory – currently the best candidate for the so-called theory of everything. The author is skeptical that such yearning for unity is supported by any empirical evidence, and may instead be turned into "dogma." He writes: "The world isn't perfect in a rational, mathematical sense. Yes, we find

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time as a result of scientific inquiry. On that telling, scientific discoveries result in overturning old regimes of order and their subsequent replacement by new regimes, where the elements of order could include determinism and indeterminism, the scope of generalizations, essentialism, reductionism, or a number of other ideals. For example, it could be argued that the Scholastic ideals of teleology and efficient engineering in biology were undermined by Darwin, but replaced with a new standard of order centered on natural selection. I believe that story is ultimately compatible with the view expressed here, where I have simply emphasized the fault lines and fracturing of some very important standards of order, such as efficiency and natural laws. I want to stress the conceptual and historical significance of that breakdown, and am open to the debate over whether the resulting metaphysical image is one of disorder *simpliciter*, or order of a new and different kind. Either way it is a radical departure from a heretofore dominant value of order.

symmetries out there, and they are useful. But we should have the humility to see Nature for what it is and not for what we want it to be."[39]

The way scientists *want* nature to be does seem like an expression of a sort of value. And what physicists want to find is partly an aesthetic consideration. The conviction that "beauty is truth, truth beauty" (to use Keats's words) may be in part aesthetic – but to treat order only as aesthetic is to fail to recognize the depth of the value. Standard discussions of "theoretical virtues" will mention elegance and simplicity as virtues of a theory.[40] Of course one is immediately curious why simple or elegant theories are more likely to be true, and those questions lead to the real significance of the value of order – the ideal that nature itself is, ultimately, well-ordered.

Lacking good evidence for that value, Gleiser proposes an alternative: "Here is a new banner, based on the beauty of imperfection: Nature creates through asymmetry." Rather than maintain faith in a "completed" science that will someday conform to the ideals of order, Gleiser, in good empiricist fashion, is willing to take the scientific results at face value. Gleiser assumes that his considerations are tantamount to "Taking the mind of God out of science" – the article's title – because the traditional conception of discovering the fundamental truths of nature have been associated with learning God's very mind. (Einstein seems to have been especially influential to modern physicists here, but clearly Einstein too is inheritor of an old tradition.) Gleiser argues that such restrictive philosophies of monism, unity, and perfection should be discarded, and he *equates* that with discarding the "mind of God" pursuit. The theist, however, who believes that nature does reveal something significant about God, might instead need to alter her theory of what exactly "God's mind" (to use Gleiser's Einsteinian language) is supposed to be like. The lack of perfect symmetries here may indicate something important not just about physics but about theology.

6. Conclusion

The elements emphasized as *order* in this paper, namely efficiency, simplicity, and universality, are kinds of order according to which, among several early modern

[39] Gleiser 2010.
[40] Churchland 1985.

philosophers, a single principle suffices to account for the widest possible range of phenomena. Leibniz thought that such principles of order were especially satisfying to reason, and were constitutive of God's optimal natural order. I have pointed out some reasons to dispute that version of nature's order.

I have tried to illustrate how an attractive branch of metaphysics and the philosophy of science have challenged the erstwhile view that the world is an integrated machine whose transcendent order is dictated by fundamental laws of nature. Metaphysical nomological pluralism supposes laws act locally on a rich assortment of objects. Depending on how nature figures into theology, one possible result is that God himself is not a divine engineer, but instead more like a divine artist – a God for whom diversity and abundance are their own ends. That recognition would remove much of the sting from criticisms which allege that God is not being sufficiently rational or engineer-like when he creates the world we find before us. Human appendices, for example, are redundant and superfluous now – they exemplify what Kitcher labels a "bungling"[41] method of creation, if this evolutionary method were indeed that of a creator. "I wouldn't have done it that way" is the kind of refrain annunciated in these criticisms. Such criticisms are best analyzed as, "If I were an omniscient engineer whose goal was to most efficiently put together the parts of the world, then I would have done it differently." I have sought to show a theistic response which maintains that logic of engineering is not the best characterization of God's activities. Moreover, I have suggested that the very reasons we might have for expecting this engineering God are based on problematic metaphysics which, if replaced, might allow novel and improved accounts of God's creative nature.

I have argued that "dappled" metaphysics might support a distinct view of God, and that such a God could be compatible with Christian traditions emphasizing God as *artifex*. Of course there have been several versions of theistic evolution, but these tend to be *ad hoc*, tacking God onto the tail end of any scientific advance, and insufficiently motivated by any broader metaphysical framework.[42] This alternative account may remedy such problems.

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[41] Kitcher 2007, p. 126.
[42] See, e.g., Asa Gray 1860.

Theologians have just begun the task of incorporating the empirical realities of the disordered world as we actually find it into a theological framework. What work exists has focused on the biological realm, though I believe many of their conclusions can and must be extended to other areas of science as well. Theologians Arthur Peacocke and John Haught have emphasized elements of "play" and "creativity"[43] in God's work, yet their accounts do not go far enough in altering the pervasive expectations of a nomically regular world. God's "play" remains counterintuitive – or worse, even maniacal – given background assumptions about the *sort* of designing the Deity must be engaged in. If God constructs the world as an omniscient engineer, there seems to be little room for creativity and play. I argue, instead, that such creative attributes are not exceptions to the rule, but more like what we ought to expect of God when we take into account a philosophy of nature in which order does not play the foremost role.

By associating God's intentions only with the *order* in our world, a theology based only on designed order threatens to attribute disorder to the demonic. But this constitutes an unacceptable limitation on God's creative capacities – one that apparently rules out His action from much of the world, and perhaps most visibly from the biological world. As noted by John Haught, "by exonerating ultimate reality of any complicity in chaos, such a theology removes God from the flow of life itself."[44] A more robust theology will acknowledge God's presence not only in the order, but in the richness of disorder as well.

Christian theology should be able to incorporate scientific findings and reflect in an illuminating fashion on their theological significance. If the universe can be understood as an expression of the heart and mind of God,[45] then our conceptions of God must be sensitive to the nature of our universe. Insofar as natural sciences give us insights into those metaphysical questions, the philosophy of science has much to contribute to theological discussions. Major changes in the philosophy of science, such as the growing understanding that a few fundamental laws imposing order over nature are at the heart of neither scientific practice nor its findings, require further articulation in theological contexts as well.

[43] Peacocke 1998.
[44] Haught 2008, p. 5.
[45] Ward 1996, Murphy 1997.

References

Ayala, Francisco. 2007. *Darwin's Gift: to Science and Religion.* Joseph Henry Press.

Barrett, P., et al. 1987. *Charles Darwin's Notebooks 1836-1844*. Cambridge: Cambridge University Press.

Beatty, John. 1995. 'The Evolutionary Contingency Thesis.' In Gereon Wolters and James G. Lennox (eds.), *Concepts, Theories, and Rationality in the Biological Sciences*, The Second Pittsburgh-Konstanz Colloquium in the Philosophy of Science, University of Pittsburgh Press.

Beatty, John. 2006. “Chance Variation: Darwin on Orchids” *Philosophy of Science* 73: 629-641.

Bird, A. 2005. ‘The Dispositionalist Conception of Laws’, *Foundations of Science*, 10, 353-370.

Becker, Carl L. 1932. *The Heavenly City of the Eighteenth-Century Philosophers*. New Haven: Yale University Press.

Behe, Michael. 2007. *The Edge of Evolution*. New York: Free Press.

Carroll, Sean. 2007. “God as Genetic Engineer” *Science*. 8 June 316: 1427-8.

Cartwright, Nancy. 1999. *The Dappled World*. Cambridge: Cambridge University Press.

Cartwright, Nancy. (forthcoming) “God’s Order, Man’s Order and the Order of Nature.” In *Science, Reason, and Truth*.

Churchland, Paul. 1985. “The Ontological Status of Observables: In Praise of the Superempirical Virtues” in Churchland et al. (eds.) *Images of Science: Essays on Realism and Empiricism*. University of Chicago Press.

Darwin, Charles. [1877] 1988. “The various contrivances by which orchids are fertilized by insects.” In *The Works of Charles Darwin*, V. 17. London: W. Pickering.

Darwin, Charles. 2003. *On the Origin of Species.* 1st ed. Cambridge: Harvard University Press.

Darwin, Charles. 1872. *On the Origin of Species*. 6th ed., rev. London: John Murray.

Darwin, Charles. 1969. *Autobiographies*. Nora Barlow, ed. New York: Norton.

Dupre, John. 1993. *The Disorder of Things.* Cambridge: Harvard University Press.

Dupre, John. 2003. *Darwin’s Legacy*. Oxford: Oxford University Press.

Desmond, Adrian and James Moore. 1991. *Darwin*. London: Michael Joseph.

Ellis, B. 2002, *The Philosophy of Nature: A Guide to the New Essentialism*, McGill-Queen's University Press.

Funkenstein, Amos. 1986. *Theology and the scientific imagination from the Middle Ages to the seventeenth century*. Princeton University Press.

Gleiser, Marcelo. 2010. "Taking the Mind of God Out Of Science" National Public Radio, May 5. http://www.npr.org/blogs/13.7/2010/04/taking_the_mind_of_god_out_of.html Accessed May 1, 2010

Gray, Asa. [1860] 1963. "Natural Selection is Not Inconsistent with Natural Theology." In *Darwiniana: Essays and Reviews Pertaining to Darwinism*. Cambridge, MA: Harvard University Press.

Haught, John. 2008. *God after Darwin: a theology of evolution*. Boulder: Westview Press.

Kincaid, Harold, John Dupre, and Alison Wylie (eds.) 2007. *Value-free science? Ideals and illusions.* Oxford University Press.

Kitcher, Philip. 2007. *Living with Darwin.* Oxford: Oxford University Press.

Gerhardt, C.I. (ed.) 1960. *Die philosophischen Schriften von Gottfried Wilhelm Leibniz*. 7 vols. Berlin: Weidmann, 1875. Repr. Hildesheim: Georg Olms.

Lewens, Tim. 2007. *Darwin*. New York: Routledge.

Maritain, Jacques. 1962. *Art and Scholasticism*. New York: Scribner.

Milton, J.R. 1998. "Laws of Nature" in Garber, Daniel and Michael Ayers (eds.) *The Cambridge History of Seventeenth Century Philosophy.* Cambridge University Press.

Mitchell, Sandra .D. 1997. "Pragmatic Laws" in L. Darden (ed.), PSA 1996: Part II, Symposia. Papers, *Philosophy of Science* (special issue), S468–S479.

Murphy, Nancey. 1997. *Anglo-American Postmodernity: Philosophical Perspectives on Science, Religion, and Ethics.* Boulder: Westview Press.

Nichols, Aiden. 1997. *Dominican Gallery* Leominster: Gracewing Publishing.

Peacocke, Arthur. 1998. "Welcoming the 'Disguised Friend' – Darwinism and Divinity" in Ruse, Michael. *Philosophy of Biology*. Amherst, NY: Prometheus.

Pennock, Robert. 2006. "The Premodern Sins of Intelligent Design" in Clayton, Phillip (ed.) *Oxford Handbook of Science and Religion*. Oxford University Press.

Richards, Robert. 2002. *The Romantic Conception of Life*. Chicago: University of Chicago Press.

Romanes, George. 1878. A Candid Examination of Theism, 1878, Chapter IV, Section 34, http://www.gutenberg.org/files/19003/19003-h/19003-h.htm#Sect34. Accessed May 1, 2010.

Ruse, Michael. 2003. "Belief in God in a Darwinian age" in Hodge, Jonathan and G. Radick, eds., *Cambridge Companion to Darwin*. Cambridge: Cambridge University Press.

Rutherford, Donald. 1995. *Leibniz and the Rational Order of Nature*. Cambridge University Press.

Steel, D. 2008, *Across the Boundaries: Extrapolation in Biology and Social Science*. Oxford University Press.

Swinburne, Richard. 1979. *The Existence of God.* Oxford: Oxford University Press.

Van Fraassen, Bas. 1989. *Laws and Symmetry*. Oxford University Press.

Ward, Keith. 1996. *Religion and Creation*. Oxford: Clarendon Press.

Zilsel, Edgar. 1942. "The Genesis of the Concept of Physical Law" *The Philosophical Review* 51:3 pp. 245-79.