Design and the Many-Worlds Hypothesis

Robin Collins

Messiah College,

I. Introduction

In the last thirty years, the argument from the fine-tuning of the cosmos has steadily gained in popularity, often being considered the strongest single argument for the existence of God. The "fine-tuning" of the cosmos refers to the claim that the fundamental parameters or constants of physics and the initial conditions of the universe are set just right for life to occur.[(1)] To give two of many examples, if the strong force coupling constant, which determines the strength of the strong force that binds protons and neutrons together in the nucleus, were slightly less, the electrical repulsion between protons would cause all atoms except hydrogen to break apart, thus eliminating the possibility of complex life forms such as ourselves; on the other hand, if this constant were slightly greater, all the hydrogen in the early universe would have been burned to helium, thus causing stars to burn too quickly for life to evolve. Similarly, it is estimated that unless the cosmological constant were near zero to one part in 10^{120} of its "natural" value derived from current theories in particle physics, the universe would either expand too rapidly, or collapse too quickly, for life to develop.

In light of these scientific findings, many theists have argued that fine-tuning strongly supports the hypothesis that the universe was intelligently designed for life, arguing that it is highly implausible to attribute this sort of fine-tuning to chance or to claim that it needs no explanation. In response to this theistic or intelligent design explanation of the fine-tuning, however, many atheists have offered an alternative explanation, what I will call the many-universes hypothesis, but which in the literature goes under a variety of names, such as many-worlds hypothesis, the many-domains hypothesis, the world-ensemble hypothesis, the multiuniverse hypothesis, etc. According to this hypothesis, there are a very large--perhaps infinite --number of universes, with the fundamental parameters of physics varying from universe to universe.[(2)] Of course, in the vast majority of these universes the parameters of physics would not have life-permitting values. Nonetheless, in a small proportion of universes they would, and consequently it is no longer improbable that universes such as ours exist that are fine-tuned for life to occur.

There are two major versions of the many-universe hypothesis, what could be called metaphysical many-universe hypothesis and what could be called the physical versions. In the metaphysical versions the universes are thought to exist on their own without being generated by any physical process, whereas in the physical versions some particular real physical process is postulated that generates the many universes. Princeton University philosopher David Lewis and University of Pennsylvania astrophysicist Max Tegmark, for example, both propose a version of the metaphysical many-universe hypothesis. According to Lewis (1986), every possible world actually exists parallel to our own. Thus, for instance, there exists a reality parallel to our own in which I am president of the United States and a reality in which objects can travel faster than the speed of light. Dream up a possible scenario, and it exists in some parallel reality, according to Lewis. On the other hand, according to Tegmark's hypothesis, "everything that exists mathematically exists physically," (1998, p. 1) by which he means that every self-consistent mathematical structure is in one to one correspondence with some physical reality(1998, pp. 1-3). Tegmark calls this hypothesis the "ultimate ensemble hypothesis," and claims it explains why there exists a universe such as ours in which the laws of nature and the parameters of physics are life-permitting.

Besides these sorts of metaphysical many-universe hypotheses, a variety of physical many-universe hypotheses have also been offered. For example, one of the first many-universe models that was proposed was the so-called oscillating big bang model, which essentially is a version of the big bang theory. According to the big bang theory, the universe came into existence in an "explosion" (that is, a "bang") somewhere between 10 and 15 billion years ago. According to the oscillating big bang theory, our universe will eventually collapse back in on itself (what is called the "big crunch") and then from that "big crunch" will arise another "big bang," forming a new universe, which will in turn itself collapse, and so on. According to those who use this model to attempt explain the fine-tuning, during every cycle, the parameters of physics and the initial conditions of the universe are reset at random. Since this process of collapse, explosion, collapse, and explosion has been going on for all eternity, eventually a fine-tuned universe will occur, indeed infinitely many of them.

More recently, a variety of other physical many universe scenarios have been proposed, such as the so-called vacuum fluctuation models, first proposed by Edward Tyron (1973). According to the vacuum fluctuation models, our universe, along with these other universes, were generated by quantum fluctuations in a pre-existing superspace. Imaginatively, one can think of this pre-existing superspace as a infinitely extending ocean full of soap, and each universe generated out of this superspace as a soap-bubble which spontaneously forms on the ocean.

Even more recently, Pennsylvania State University gravitational physicist Lee Smolin (1997) has offered a many-universes scenario based on a highly speculative scenario regarding black holes. According to Smolin's speculation, by tearing and rearranging the fabric of space-time, black holes can give rise to new universes with different parameters, and even lower-level laws, of physics. Thus, once a single universe exists, it will spawn new universes via black holes, and these new universes will spawn further universes, and so-on.

Since the early 1980's, what could be called the inflationary many-universe hypothesishas steadily gained popularity, being based in so-called inflationary cosmology, which is the cosmological theory first proposed by Alan Guth in 1980 to explain the big bang and various features of the universe, such as the large-scale uniformity of matter in space. Despite the variety of many-universe scenarios that have been proposed, both metaphysical and physical, the inflationary scenario is the only one that goes beyond mere speculation. The reason is two-fold. First, unlike the other scenarios, inflationary cosmology has significant scientific evidence in its favor, being widely regarded as the most viable theory of the origin of the universe available today. Second, a many-universe scenario naturally arises out of what are widely considered the most plausible models of inflationary cosmology. So, although speculative, an inflationary many-universe hypothesis deserves to be taken particularly seriously.[(3)]

Because it is widely considered to be by far the most physically plausible scenario, we will focus on the inflationary many-universe scenario here. In the rest of this paper, we will first explain why an inflationary many-universes scenario might be able to offer a viable explanation of the fine-tuning, but then go on to explain why there still remains a powerful case for design from physics and cosmology. Further, much of the evidence for design that we will present cannot be naturally explained by any many-universe scenario, and thus circumvents any objection to design based on the many-universe hypothesis, whether the inflationary version or some other version.

II. Inflationary Many-Universe Scenario.

According to inflationary cosmology, our universe started from an exceedingly small region of space that underwent enormous expansion due to an hypothesized inflaton field which both caused the expansion and imparted a constant, very large energy density to space as it expanded. The expansion caused the temperature of space to decrease, in analogy to what happens when a gas expands. This in turn caused one or more "droplet" universes to form, much as water droplets are formed when water vapor is cooled upon expanding, as when moist air goes over a mountain range producing rain. As each droplet universe is formed, the energy of the inflaton field is converted into a burst of "normal" mass-energy thereby giving rise a standard big-bang expansion of the kind we see in our universe.

In chaotic inflation models--widely considered the most plausible--space expands so rapidly that it becomes a never ending source of droplet universes, much as a rapidly expanding, continually replenished supply of water vapor would serve as an unending source of water droplets. Thus, an enormous number of universes naturally arise from this scenario.

In order to get the initial conditions and parameters of physics to vary from universe to universe, however, there must be a further physical mechanism to cause the variation. Whether a mechanism exists that allows for enough variation to explain the fine-tuning depends on the fundamental physical theory governing elementary particles and forces. The so-called grand unified theories currently being widely explored by physicists, for instance, only allow for a very limited number of variations of the parameters of physics, about a dozen or so in the case of the simplest model. (Linde, 1990, PP&IC, p. 33). Merely to account for the fine-tuning of the cosmological constant, however, would require trillions upon trillions upon trillions upon trillions of variations, since it is estimated that it is fine-tuned to one part in 10^{120} (Guth, 1997, p. 284).[(4)]

To see this, note that, at least in the case of the cosmological constant, to say that a parameter is fine-tuned to one part in 10^{120} means that the life-permitting range of the parameter is one in 10^{120} of what physicists take as the natural range of values given by the background physical theory. Thus, to account for this fine-tuning by means of a many-universes hypothesis would require around 10^{120} variations in the parameters of physics. If, for example, there were only ten different values for the cosmological constant among the universes, we would still find it very surprising for the cosmological constant to fall into the life-permitting range in any of the universes. The same could be said for many of the other cases of fine-tuning.

Here is where superstring theory could come to the rescue. Superstring theory is widely considered the only currently feasible candidate for a truly fundamental physical theory (Greene, 1999, p. 214), and is certainly the only currently viable physical theory that seems to allow for enough variation among universes of the parameters of physics to explain the fine-tuning. According to superstring theory, the ultimate constituents of matter are strings of energy that undergo quantum vibrations in a 10 (or 11) dimensional space-time, six or seven dimensions of which are "compactified" to extremely small sizes and are hence unobservable. The shape of the compactified dimensions, however, determines the modes of vibration of the strings, and hence the types and masses of fundamental particles, along with many characteristics of the forces between them. Thus, universes in which compactified dimensions have different shapes will have different parameters of physics and differing lower-level laws governing the forces.

Now, if the universe started in an extremely high energy state, the various compactified dimensions would undergo rapid variations in shape. As the temperature of a region of expanding space cools, a droplet universe is likely to form. Such a universe will fall into a local minimum of energy, called a vacuum state, of the space of possible compactified shapes, thus determining the shape of the compactified dimensions for that universe. Consequently, the number of variations in the shape of the compactified dimensions among universes, and hence the variation in the parameters and lower-level laws of physics governing the forces is determined by the number of vacua of string theory - that is, the number of local minima of energy.. The number of vacua is unknown, but most string theorists hope that it is small so that string theory would virtually determine the parameters and laws of physics; nonetheless, as far as we know, the number could be enormous enough to explain the fine-tuning.

Thus, it is in the realm of real physical plausibility that a viable inflationary many-universes scenario could be constructed that would account for the fine-tuning of the parameters of physics and the initial conditions of the cosmos. Nonetheless, it should be noted that despite the current popularity of both inflationary cosmology and superstring theory, both are highly speculative. For instance, as Michio Kaku states in his recent textbook on superstring theory, "Not a shred of experimental evidence has been found to confirm . . . superstrings" (1999, p. 17). The major attraction of string theory is its mathematical elegance and the fact that many physicists think that it is the only game in town that offers significant hope of providing a truly unified physical theory of gravitation with quantum mechanics (Greene, 1999, p. 214).[(5)]

It should be stressed, however, that even if superstring theory or inflationary cosmology turn out to be false, they have opened the door to taking the many-universes explanation of the fine-tuning as a serious physical possibility since some other physical mechanisms could give rise to multiple universes with a sufficiently large number of variations in the parameters of physics. The only way we could close this door is if we discovered that the ultimate laws of physics did not allow either many-universes or enough variation in the parameters and laws of physics among universes.

Now that we have established the positive case for taking the many-universes hypothesis seriously as a possible explanation for the fine-tuning of the parameters of physics, we will turn to the case for design.

THE CASE FOR DESIGN

The Many-Universe Generator Needs Design

In this subsection, we will present the case for design based on the assumption that the physicalmany-universe (i.e., "universe generator") scenario is by far the most plausible. (In the next subsection, we will present the case for design that applies as well to those who find the metaphysical many-universe scenario plausible.) We begin by noting that even if a "many-universes generator" exists it seems to need to be "well-designed" in order to produce life-sustaining universes. And this is true whether such a generator is based in inflationary cosmology or something else. After all, even a mundane item like a bread machine, which only produces loaves of bread instead of universes, must be well-designed to produce decent loaves of bread.

As a test case, consider whether this line of reasoning works for the inflationary type many-universe scenario. In order for many universes to be generated in this scenario, there must be one or more mechanisms that: (i) cause the expansion of a small region of space into a very large region; that (ii) in the process allow for the generation a very large amount of mass-energy needed for a universe containing matter instead of merely empty space; and that (iii) allow for the conversion of the mass-energy of inflated space to the sort of mass-energy we find in our universe.

Glossing over the details, in inflationary models, the first two conditions are met via two factors. The first factor is the postulated inflaton field that gives the vacuum (that is, empty space), a positive energy density. The second factor is the peculiar nature of Einstein's equation of general relativity, which dictates that space expand at an enormous rate in the presence of a large near-homogenous positive energy density. Finally, because the inflaton field gives a constant positive energy density to empty space, as space expands the total amount of energy within the space in question must enormously increase. This in turn generates the needed energy for the formation of matter in the universe. As one text in cosmology explains, "the vacuum acts as a reservoir of unlimited energy, which can supply as much as is required to inflate a given region to any required size at constant energy density" (Peacock, 1999, p. 26).

So, we effectively have a sort of "conspiracy" between at least two different factors: the inflaton field that gives empty space a positive energy density, and Einstein's equation. These two harmoniously work together to enormously inflate small regions of space while at the same time imparting to them the positive energy density necessary for a universe with significant mass-energy. Without either factor, there would neither be regions of space that inflate nor would those regions have the mass-energy necessary for a universe to exist. If, for example, the universe obeyed Newton's theory of gravity instead of Einstein's, the vacuum energy of the inflaton field would at best simply create a gravitational attraction causing space to contract, not to expand.[(6)] Finally, Einstein's equivalence of mass and energy, $E = mc^2$, along with an assumption that there is a coupling between the inflaton field and the matter fields, allows the energy of the inflaton field to be converted to "normal" mass-energy.

In addition to the above conspiracy of factors, the initial state of space that generates the many universes must start with a high value for the energy density of the inflaton field. For example, if the inflaton field started out at a near zero value, as is its current value in our universe, no inflation could occur.

Moreover, as we saw above, there must be some mechanism that allows for enough variation in the parameters of physics to account for the fine-tuning. This would require that the fundamental structure of physical law have the right form, as might be the case in string theory but not, for example, in the typical grand unified theories that are being studied today, as mentioned above. As Joseph Polchinski notes in his textbook on string theory (1998, Vol. II, pp. 372-73), there is no reason to expect a generic field to have an enormous number of stable local minima of energy, which would be required if there is to be a large number of variations in the parameters of physics among universes.

In addition to all this, some of the background laws of physics must be right for the universes generated to be life-permitting. For example, without the principle of quantization, all electrons would be sucked into the atomic nuclei and hence atoms would be impossible; without the Pauli-exclusion principle, electrons would occupy the lowest atomic orbit and hence complex and varied atoms would be impossible; without a universally attractive force between all masses, such as gravity, matter would not be able to form sufficiently large material bodies (such as planets) for life to develop or for long-lived stable energy sources such as stars to exist.

Although some of the laws of physics can vary from universe to universe in string theory, these background laws and principles form part of the very structure of string theory and therefore cannot be explained as a many-universes selection effect. Further, since the variation among universes would consist of variation of the masses and types of particles, and the form of the forces between them, complex structures would almost certainly be atom-like and stable energy sources would almost certainly require aggregates of matter. Thus, the above background laws seem necessary for there to be life in any of the many-universes generated in this scenario, not merely a universe with our specific types of particles and forces.

In sum, even if an inflationary/superstring many-universe generator exists, it along with the background laws and principles could be said to be an irreducibly complex system, to borrow a phrase from biochemist Michael Behe (1996), with just the right combination of laws and fields for the production of life-permitting universes: if one of the components were missing or different, such as Einstein's equation or the Pauli-exclusion principle, it is unlikely that any life-permitting universes could be produced. In the absence of alternative explanations, the existence of such an a system suggests design.

It should also be noted that the inflationary scenario does not explain where the mass-energy of the universe, and the laws of physics, came from. The answer that it always existed is most likely ruled out within inflationary scenarios. (See Guth, 1997, p. 249 and Guth, 2000, p. 16.) This suggests a need for a an ontologically transcendent being that is responsible for the existence of the universe, though we will not pursue this form of the cosmological argument here.

Finally, it should be stressed that theists need not be opposed to the inflationary many-universe hypothesis. Indeed, there are several reasons theists could give in support of a theistic version of it. First, as described above, the fact that so many factors in contemporary cosmology and particle physics conspire together to make the inflationary many-universe scenario viable gives theists significant reasons for taking it as a serious possibility. Second, science has progressively shown that the visible universe is vastly larger than we once thought, with a current estimate of some 300 billion galaxies with 300 billion stars per galaxy. Thus, it makes sense that this trend will continue and physical reality will be found to be much larger than a single universe. Finally, since theists have traditionally believed that God is infinite and infinitely creative, it only makes sense that creation would reflect these attributes of God, and hence that physical reality would be much larger than one universe, perhaps even infinitely larger.

Apparent Design of Physical Law

Next, we will turn to the various features of the laws of nature that both suggest design and cannot be explained by any many-universes hypothesis, whether physical or metaphysical. We will only be able to give the briefest sketch of them here, however. These features of the laws are: (i). their simplicity; (ii) their beauty, harmony and elegance; (iii) their intelligibility; and (iv) what I will call their "discoverability."

We will begin with the simplicity of the laws. Although no adequate definition of what is meant by calling the laws of nature simple has ever been given, both scientists and philosophers almost unanimously agree that they manifest a surprising degree of simplicity. Indeed, when constructing a new law of nature in some domain, scientists routinely look for the simplest law that adequately accounts for the extant data and which meets the other constraints imposed by various background assumptions.

Besides simplicity, there is also the beauty of the laws of nature. As Nobel prize winning theoretical physicist Steven Weinberg stresses in his book Dreams of a Final Theory(1992), beauty is widely recognized by physicists as being an important characteristic of the laws of nature, one which has served as a highly successful guide to discovering the fundamental laws of nature in the 20th century. Indeed, Weinberg devotes all of chapter six of his book to discussing and emphasizing the role that considerations of beauty have played in physics. Weinberg, who is a convinced atheist, even admits that "sometimes nature seems more beautiful than strictly necessary" (1992, p. 250).

This use of beauty and elegance as a fundamental guiding principle was to a large extent inaugurated by Einstein in his development of general relativity, though it was certainly implicitly used by earlier physicists. For example, following Einstein's lead, Paul Dirac, one of the most important figures in the development of quantum mechanics is the 20^{th} century, made mathematical beauty the foremost criterion in developing a physical theory. According to theoretical physicist and historian of physics Oliver Darrigol,

the notion of mathematical beauty was an integral part of ...[Dirac's] strategy. [According to Dirac,] one first had to select the most beautiful mathematics--not necessarily connected to the existing basis of theoretical physics--and then interpret them in physical terms (1992, p. 304).

Today, this use of beauty and elegance as a guide is particularly evident in the popularity of string theory, which as mentioned above is almost entirely motivated by considerations of elegance, having no experimental support in its favor.

As embodied in the mathematical structure of physical theory, some of these elements of beauty are: (i) simplicity with variety; (ii) proportion and harmony; (iii) symmetry; (iv) inevitability; (v) ingenuity; and (v) having an "interesting twist" or a "strangeness of proportion."[(7)]

The above elements are largely constitutive of the so-called classical concept or type of beauty, but I will only significantly discuss that of simplicity with variety here. Simplicity with variety was the defining feature of beauty or elegance stressed by William Hogarth in his 1753 classic The Analysis of Beauty, where he famously used a line drawn around a cone to illustrate this notion. According to Hogarth, simplicity apart from variety, such as a straight line, is boring, not elegant or beautiful.

Now, the laws of nature seem to manifest just this sort of simplicity with variety: we inhabit a world that could be characterized as a world of fundamental simplicity that gives rise to the enormous complexity needed for intelligent life. In physics, this simplicity with variety is particularly evident in the way in which whole classes of divergent physical phenomena and laws of nature are encompassed by common contingent principles of great simplicity and elegance. For instance, consider the so-called gauge principle of fundamental particle physics which undergirds our current understanding of at least three, and arguably all four, of the four forces of nature. The mathematical form of three of the four forces of nature, the strong force, the weak force, and electromagnetism, all obey the gauge principle, and the gauge principle served as a crucial guide in constructing the modern theory of these forces. Further, a principle very much like the gauge principle is what guided Einstein in the construction of his theory of general relativity, which is currently our best theory of the gravitational force. Yet, as Ian Atchison and Anthony Hey point out in their text Gauge Theories in Particle Physics, there is no compelling logical reason why this principle must hold (1989, pp. 59- 60). Rather, they claim, this principle has been almost universally adopted as a fundamental principle in elementary particle physicists because it is "so simple, beautiful and powerful (and apparently successful)" (1989, p. 60). Further, as Alan Guth points out, the original "construction of these [gauge] theories was motivated mainly by their mathematical elegance" (1997, p. 124). Thus, the gauge principle provides a good example of a contingent principle of great simplicity and elegance that encompasses a wide range of phenomena, namely the interactions between all the particles in the universe.[(8)]

Other examples of principles that encompass large classes of divergent phenomena are the law of energy conservation, the least action principle, the second law of thermodynamics, various quantum principles, such as the superposition principle and the Pauli-exclusion principle, and the like. Further, though we will not argue in detail for it here, it does not seem that one can plausibly think of these principles as in themselves having any causal power to dictate the lower-level phenomena or laws. Rather, the "causation" or dependence is in the other direction: it's because the laws and phenomena are what they are that these principles universally hold, not the other way around. An analogy from architecture might be helpful to illustrate this point: insofar as the placement of windows in a building follow higher-level principles, it is not because the principles somehow in themselves have a special power to make the windows have the right positions. Rather, it is because of the position of the windows that the higher-level principles hold. Further, insofar as the higher-level principles could be said to have a causal efficacy to determine the placement of the windows, it is only via the causal powers of an intelligent agent, such as the people who constructed the building.

One reason for claiming that these principles have no intrinsic causal powers is that except for being an intention or thought in some mind, human or transcendent, it is difficult to see how these higher-level principles could be anything over and above merely the patterns into which the laws and phenomena of nature fall. For example, they do not appear to be reducible to the causal powers of actual entities, as some philosophers claim about the laws of nature.[(9)] Instead, insofar as entities possess causal powers, the principles describe the arrangement of the causal powers of a diverse class of such entities--e.g., the fundamental particles--and therefore cannot be the powers of any given entity.

Thus, just as the positions of windows in a building are often arranged just right so that certain higher-level architectural principles are met, the laws of nature and various phenomena give the appearance of being arranged just right, or even "fine-tuned," so that a few simple, higher-level physical principles are universally valid. Although this idea of the laws being arranged just right or "fine-tuned" is difficult rigorously to spell-out, several specific examples will help illustrate the idea. One example that is often cited is the so-called peaceful coexistence of the principles of special relativity with those of quantum mechanics, which many authors have pointed out is quite "miraculous," since it depends on certain special features of quantum dynamics--namely, the absolute linearity of the central equation of quantum mechanics, the Schrödinger equation, and the particular form of the rule governing the so-called "collapse of the state vector."[(10)]

Another example occurs with the gauge-principle mentioned above, in which many of the laws and phenomena of physics, such as the mathematical form of the forces between elementary particles, are arranged in just the right way for the gauge principle to apply. A particularly interesting case of this occurs with regard to the weak force. The gauge-principle applies in a relatively straightforward way to electromagnetic and strong force, but initially it appeared that it could not be used to determine the mathematical form of the weak force, which is one of the four forces of nature and is responsible for many cases of the transmutation and decay of nuclei and elementary particles. The problem was that a straightforward application of the gauge principle requires that the particle carrying the weak force be massless, which in turn implies that the weak force would be long range. Not only was this contrary to the experimental data, but if the weak force were long range, life would probably be impossible.[(11)] It took ten years for physicists to see their way around this problem. Using the previous work of Sheldon Glashow, Steven Weinberg and Abdus Salem developed a solution: introduce a new field, called a Higgs field, with a special mathematical form, often referred to as a "mexican hat" potential because when represented on a graph its form resembles that of a mexican hat. The introduction of this field allowed Weinberg and Salem not only to apply the gauge principle to the weak force, but it allowed them to produce a theory that unites the electromagnetic and weak force, the so-called Glashow-Weinberg-Salem electroweak theory. This theory has since been significantly confirmed by experiment.

Without the Higgs field, therefore, one would either not have an extremely short-range force like the weak force, which as mentioned above would probably mean a lifeless universe, or the gauge-principle would be violated. Once again, the point of this example is that nature appears to be arranged in just the right way -- such as by including a Higgs field of right form-- to guarantee that certain simple higher-level principles are satisfied, while at the same time guaranteeing a life-permitting universe.

Theoretical physicist Paul Davies offers even further examples of this sort of seemingly ingenious construction of nature that allow the higher-level principle of physics to remain valid, even in very bizarre circumstances. For example, he discusses how black holes initially appear to violate the second law of thermodynamics, but that upon further careful and subtle analysis, "it turns out not to be so, but only when quantum physics is taken into account" (1984, p. 231). Thus, Davies concludes, "The three branches of physics [general relativity, quantum mechanics, and thermodynamics] mutually support each other, even for a system as bizarre as a black hole . . . . The black hole provides a good example, then of how physics hang together coherently, sometimes for the most subtle of reasons" (1984, p. 231).

Finally, as further testimony to the above point, consider what Steven Weinberg and other physicists have called the "inevitability" of the laws of nature. (e.g. see Weinberg, 1992, pp. 135-153, 235-237). The inevitability that Weinberg refers to is not the inevitability of logical necessity (1992, p. 235), but rather that the mathematical structure of the laws of nature are encompassed by a few general principles, as with the gauge-principle discussed above. The reason Weinberg refers to this as the "inevitability" of the laws of nature is that the requirement that these principles be met often severely restricts the possible mathematical forms the laws of nature can take, thus rendering them in some sense "inevitable." This inevitability of the laws is particularly evident in Einstein's general theory of general relativity. As Weinberg notes, "once you know the general physical principles adopted by Einstein, you understand that there is no other significantly different theory of gravitation to which Einstein could have been led." (1992, p. 135) As Einstein himself said, "To modify it [general relativity] without destroying the whole structure seems to be impossible." (Quoted in Weinberg, 1992, p. 135.)

One way of thinking about this inevitability is as a sort of fine-tuning. If one imagines a space of all possible laws, the set of laws and physical phenomena we have are just those that meet the higher-level principles. Of course, in analogy to the case of the fine-tuning of the parameters of physics, there are bound to be other sets of laws that meet some other relatively simple set of higher-level principles. But this does not take away from the fine-tuning of the laws, or the case for design, anymore than the fact that there are many possible elegant architectural plans for constructing a house takes away from the design of a particular house. What is important is that the vast majority of variations of these laws end up causing a violation of one of these higher-level principles, as Einstein noted about general relativity. Further, for those who are aware of the relevant physics, it is easy to see that in the vast majority of such cases, such variations do not result in new, equally simple higher-level principles being satisfied. It follows, therefore, that these variations almost universally lead to be less elegant and simple set of higher-level physical principles being met. Thus, in terms of the simplicity and elegance of the higher-level principles that are satisfied, the laws of nature we have appear to be a tiny island surrounded by a vast sea of possible law structures that produce a far less elegant and simple physics.

Now, this simplicity and elegance cannot be explained by many-universes hypothesis, since there is no reason to think that intelligent life could only arise in a universe with simple, elegant underlying physical principles. Certainly a somewhat orderly macroscopic world is necessary for intelligent life, but there is no reason to think this requires a simple and elegant underlying set of physical principles. This is especially clear when one considers how radically different the framework and laws of general relativity and quantum mechanics are from the world of ordinary experience: although the regularities of the everyday world are probably derived from the underlying laws of quantum mechanics and general relativity, they do not reflect the structure of those laws. Indeed, it is this that has largely given rise to the different interpretive problems of quantum mechanics and general relativity. Thus, the there is little reason to expect the sort of macroscopic order necessary for intelligent life to be present in the underlying, microscopic world.

In sum, therefore, the apparent delicate arrangement and fine-tuning of the laws of nature in order to meet a few simple, contingent, higher-level principle seem strongly to suggest design. As theoretical physicist Paul Davies notes with regard to these features of the laws of nature,

A common reaction among physicists to remarkable discoveries of the sort discussed above is a mixture of delight at the subtlety and elegance of nature, and of stupefaction: 'I would never have thought of doing it that way.' If nature is so 'clever' it can exploit mechanism that amaze us with their ingenuity, is that not persuasive evidence for the existence of intelligent design behind the physical universe? If the world's finest minds can unravel only with difficulty the deeper workings of nature, how could it be supposed that those workings are merely a mindless accident, a product of blind chance?....Once again, the crossword puzzle analogy is appropriate here. Uncovering the laws of physics resembles completing a crossword in a number of ways.... In the case of the crossword, it would never occur to us to suppose that the words just happened to fall into a consistent interlocking pattern by accident..." (1984, pp. 235-36)

Another feature of the fundamental structure of the physical world that seems to suggest design is its intelligibility. As Albert Einstein once remarked, "the most unintelligible thing about the universe is that it is intelligible at all." One aspect of this intelligibility is the fact that those human intuitions, categories and concepts we consider significant apply surprisingly well and serve as surprisingly good guides to the underlying order of things. We have already seen this in the applicability of the categories of simplicity and beauty to the underlying order, which are special cases of this more general notion of the intelligibility of nature. This more general notion also includes human intuitions about the way nature should be, along with additional categories such as naturalness, all of which are central to both theory confirmation and development. As Albert Einstein remarked, "There is no logical path leading to these laws [of nature], but only intuition, supported by sympathetic understanding of experience." (Quoted in Arthur Miller, Insights of Genius, p. 369).

The final way in which the laws of nature and the structure of physical reality suggest design is in what I will call their discoverability: that is, the laws of nature seem to be carefully arranged so that they are discoverable by beings with our level of intelligence. I believe that this feature of the laws not only suggests design, but that it fits into a larger pattern that suggests a particular providential purpose for human beings, such as that of developing a sophisticated science and technology, but I cannot argue for that here.

Of course, the fact that the fundamental structure of the world displays a simplicity, elegance, and intelligibility greatly contribute to its discoverability, as we have indicated above. Although we cannot present them here, more specific examples of this "fine-tuning" for discoverability are presented by philosopher Mark Steiner in his book, The Applicability of Mathematics as a Philosophical Problem, in which he concludes that the world much more "user-friendly" than seems explicable under naturalism (1998, p. 176). Although I do not think that Steiner has yet made an entirely compelling case, his work does show, I believe, that there is a significant case to be made for the discoverability of the laws of nature, a case that needs be spelled-out by further research.

Alternative Non-design Explanations

Above we have claimed that the simplicity, beauty, intelligibility, and discoverability of the laws of nature all point to design. But there are alternative explanations. For brevity's sake, we will primarily focus on these alternatives for the case of beauty.

The first alternative explanation is to claim that this so-called beauty is purely subjective, simply the result of our reading into nature anthropomorphic patterns in the same way as humans have read various meaningful patterns--such as the Bear or the Big Dipper--into the random pattern of stars in the night sky. The major problem with this explanation is that it does not account for the surprising success of the criterion of beauty in the physical sciences. Patterns that are merely subjective do not serve as a basis for highly accurate predictions that are clearly objective, such as quantum electrodynamics's successful prediction, to nine significant digits, of the quantum correction to the g-factor of the electron. The second problem is that there are significant objective aspects of beauty, at least in the classical sense of beauty, that one can clearly demonstrate in the realm of physics, such as that of symmetry.

The second attempt at offering an alternative explanation is to invoke evolution, claiming that long before the rise of science, natural selection programmed into us the category of beauty because it was of survival value. Although evolution might be able to explain why we have a category of beauty, it cannot explain why it applies so well to the underlying order of the world, since such applicability was obviously irrelevant to our survival during the long course of human evolution. At most, evolution can only explain why beauty applies to the everyday world of those things necessary for our survival. But, as often noted, it is in the underlying world that considerations of beauty as a guide have met with the most impressive success, at least in terms of producing theories that are extraordinarily predictively fruitful. This is just the opposite of what this evolutionary explanation would lead one to expect. Further, this evolutionary explanation leaves unexplained why the underlying world exhibits those objective features--such as simplicity with variety, symmetry, harmony and proportion so characteristic of beauty. Theism, in contrast, naturally explains these characteristics, and thus provides a better explanation of them.

A second kind of evolutionary explanation is that presented by Steven Weinberg: through a process of trial and error since the scientific revolution, we have learned that nature is a certain way, and then we have come to consider the way nature is beautiful (1992, p. 158). That is, Weinberg suggests that after the scientific revolution, scientists unconsciously modified their criteria of beauty to fit nature. The problem with this explanation is that we can point to objective features of underlying world--its symmetry, its simplicity in variety, its inevitability--that clearly fit the general criteria of the so-called classical conception of beauty, a category of great human significance that originated long before the scientific revolution. Further, the mere fact that scientists use the term "beautiful" instead of some other category to describe the underlying order indicates that they sense a deep congruence between the order of nature and those features normally associated with beauty in other, non-scientific contexts. It is this congruence that Weinberg's evolutionary explanation fails to explain.

The third alternative explanation invokes some metaphysical principle of beauty and simplicity -- such as that the basic structure of the world is more likely to be simple and beautiful than complex and ugly-- to account for the simplicity and beauty of the laws. Not only does such a principle seem implausible, but it would need to be supplemental with a parallel principle to account for the intelligibility and discoverability of the laws of nature, along with a many-universes hypothesis to account for the fine-tuning for life of the parameters of physics. The only way I can see of making the existence of such principles plausible is by appealing to some unified overarching hypothesis that implies these lower-level principles, such as the theistic hypothesis.

The final alternative is merely to claim that the simplicity and beauty of the laws of nature is simply a brute fact that requires no explanation. One could always adopt this position, but then given that theism naturally explains these features of the laws of nature, the atheist must admit that theism offers a better explanation of them than atheism, and thus that they support theism over atheism. Why? Because a natural, non-ad hoc explanation of a phenomenon x is always better than no explanation at all. And theism does seem to offer such a natural explanation: for example, given the classical theistic conception of God as the greatest possible being, and hence a being with a perfect aesthetic sensibility, it is not surprising that such a God would create a world of great subtlety and beauty at the fundamental level.

These non-design responses get even more implausible when we consider other aspects of the laws of nature that suggest design, such as their discoverability and intelligibility. An even further implausibility arises when we reflect on the emergence within our universe of consciousness and highly abstract and theoretical thought as occurs in philosophy, mathematics, and advanced physics, something seemingly inexplicable by an unguided evolutionary process since it does not appear either to have been of any survival value, or to be a natural byproduct of anything of significant survival value, during the long course of human biological evolution.[(12)] This is especially true given the strong case that can be made for the irreducibility of consciousness to physical processes or states.

Conclusion

Finally, it is worth reflecting on the sort of inference that we have invoked in our argument. It involves what philosophers call a cumulative case argument in which many factors, such as the fine-tuning, the simplicity, the beauty, the intelligibility, and discoverability of the laws of nature, all point in the same direction, and seem difficult to explain on any other hypothesis. In this sense, the above case is very similar to the sort of arguments offered for scientific theories, such as the theory of evolution by descent with modification. As evolutionary biologist and geneticist Edward Dodson summarizes the case for evolution,

All [pieces of evidence] concur in suggesting evolution with varying degrees of cogency, but most can be explained on other bases, albeit with some damage to the law of parsimony. The strongest evidence for evolution is the concurrence of so many independent probabilities. That such different disciplines as biochemistry and comparative anatomy, genetics and biogeography should all point toward the same conclusion is very difficult to attribute to coincidence" (p. 68).

The case for design as I presented it is of the same form and, I believe, will be found to be of comparable strength upon further research and elaboration.

References

Aitchison, Ian and Hey, Anthony. Gauge Theories in Particle Physics : a Practical Introduction 2nd Edition, Bristol, England: Adam Hilger Publishing Company, 1989.

Barrow, John and Tipler, Frank. The Anthropic Cosmological Principle. New York: Oxford University Press, 1986.

Behe, Michael. Darwin's Black Box: The Biochemical Challenge to Evolution. New York: The Free Press, 1996.

Chandrasekhar, S. Truth and Beauty: Aesthetics and Motivations in Science, Chicago, IL: University of Chicago Press, 1987.

Darrigol, Oliver. From c-Numbers to q-Numbers: The Classical Analogy in the History of Quantum Theory, Los Angeles, CA: University of California Press, 1992.

Davies, Paul. Other Worlds: a Portrait of Nature in Rebellion, Space, Superspace, and the Quantum Universe. New York: Simon and Schuster, 1980.

__________. The Accidental Universe. Cambridge: Cambridge University Press, 1982.

__________ Superforce: The Search for a Grand Unified Theory of Nature. New York: Simon and Schuster, 1984.

Davies, P. C. W. and Brown, J. Superstrings: A Theory of Everything? Cambridge: Cambridge University Press, 1988.

Davies, P. C. W. "The Intelligibility of Nature." In Quantum Cosmology and the Laws of Nature: Scientific Perspectives on Divine Action, second edition, edited by Robert Russell, et. al., Berkeley, CA: The Center for Theology and the Natural Sciences Publications, 1993.

Dodson, Edward. The Phenomena of Man Revisited: a Biological Viewpoint on Teilhard de Chardin, New York: Columbia University Press, 1984.

Earman, John and Mosterin, Jesus. "A Critical Look at Inflationary Cosmology," Philosophy of Science, 66, March 1999, pp. 1-49.

Greene, Brian. The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory. New York: W. W. Norton and Company, 1999.

Guth, Alan. The Inflationary Universe: The Quest for a New Theory of Cosmic Origins. New York, Helix Books, 1997.

________. "Inflation and Eternal Inflation," at the government astrophysics website, http://arXiv:astro-ph/0002156, February 2000.

Harré, Rom and Madden, Edward. Causal powers : A Theory of Natural Necessity, Oxford, England: Basil Blackwell, 1975.

Hogarth, William. The Analysis of Beauty, 1753.

Kaku, Michio. Introduction to Superstrings and M-Theory, Second Edition. New York, Springer-Verlag, 1999.

Leslie, John. Universes. New York : Routledge, 1989.

Lewis, David. On the Plurality of Worlds, New York, Basil Blackwell, 1986.

Linde, Andrei. Particle Physics and Inflationary Cosmology. Translated by Marc Damashek. Longhorne, Pennsylvania: Harwood Academic Publishers, 1990.

Linde, Andrei. Inflation and Quantum Cosmology. New York: Academic Press, Inc., 1990.

Miller, Arthur. Insights of Genius: Imagery and Creativity in Science and Art. New York : Copernicus, c1996.

Nagel, Thomas. The Last Word New York: Oxford University Press, 1997.

Peacock, John. Cosmological Physics. Cambridge, UK: Cambridge University Press, 1999.

Plantinga, Alvin. Warrant and Proper Function. Oxford: Oxford University Press, 1993.

Polchinski, Joseph. String Theory. Vol. I and II. Cambridge Monographs in Mathematical Physics. (Cambridge University Press, 1998.)

Rozental, I. L. Big Bang, Big Bounce: How Particles and Fields Drive Cosmic Evolution. New York, NY: Springer-Verlag, 1988.

Smolin, Lee. The Life of the Cosmos, New York : Oxford University Press, 1997.

Steiner, Mark. The Applicability of Mathematics as a Philosophical Problem. Cambridge, MA: Harvard University Press, 1998.

Tegmark, Max. "Is 'the theory of everything' merely the ultimate ensemble theory?", Annals of Physics, 270, (1998), pp. 1-51.

Tyron, Edward. "Is the Universe a Vacuum Fluctuation?" Nature, vol. 246, pp. 396-7 (1973).

Weinberg, Steven. Dreams of a Final Theory. New York: Vintage Books, 1992.

Zee, A. Fearful Symmetry: The search for Beauty in Modern Physics. Princeton, NJ: Princeton University Press, 1986.

1. The fundamental parameters or constants of physics are the fundamental numbers-such as the gravitational constant G in Newton's law of gravity, $F = Gm_1m_2/r^2$, that help determine the basic structure of the universe. For a careful development of the fine-tuning argument, see my "The Fine-tuning Design Argument," in Michael Murray, editor,Reason for the Hope Within, Eerdmans Press, 1999. For some

substantial treatments of the evidence of fine-tuning, see Leslie (1989), Davies (1982, 1984), and Barrow and Tipler (1986), Rozental (1988).

2. I define a "universe" as any region of space-time that is disconnected from other regions in such a way that the parameters of physics in that region could differ significantly from the other regions.

3. For a critique of inflationary cosmology, see John Earman and Jesus Mosterin, 1999. For an accessible introduction to inflationary cosmology, see Alan Guth, 1997. For recent experimental confirmation of inflationary cosmology, see "Cosmology from Maxima-1, Boomerang and COBE/DMR CMB Observations," July 2000, at the astrophysics website, http://arXiv.org/abs/astro-ph/0007333.

4. The cosmological constant is a fundamental physical parameter that can be thought of as corresponding to the energy density of empty space.

5. The sort of inflationary/superstring many-universe explanations of the fine-tuning discussed above have been suggested by a number of authors, such as Linde, (1990, PP&IC, p. 306; 1990, IQC, p. 6) and Greene (1999, pp. 355 - 363). To date, however, no one has adequately verified or worked-out the physics of superstring theory or inflationary cosmology, let alone the combination of the two, so this scenario remains highly speculative.

6. In addition, the near-homogenous energy density requirement imposed by the particular form of Einstein's equation guarantees an almost smooth early universe which probably is essential for the development of life. (As Davies argues, even a small amount of turbulence in the early universe would most likely generate too much heat for life to develop [1980, pp. 156-161]) Further, however, the existence of quantum perturbations, guarantees that the universe is not completely smooth, and hence allows for the formation of galaxies which are almost certainly dependent on slightly inhomogeneous distributions of mass-energy in the early universe. (See Rozental, 1988, pp. 48-53). Thus, the particular form of Einstein's equation, along with the principles of quantum mechanics, work together to allow the right amount of inhomogenuities to develop. If, for instance, Einstein's equation required an inhomogeneous energy density for inflation to occur, it is unlikely that inflation could produce any life-permitting universes.

7. For example, see S. Chandrasekhar, 1987, chapter 4, for a discussion of this criterion. Also see A. Zee, 1986, for a very accessible account of the role that considerations of beauty have played in modern physics.

8. The gauge principle is highly technical and difficult to understand without much advanced training in physics, and thus beyond the scope of this paper to further explain.

9. For example, see Rom Harré and Edward Madden, 1975.

10. See, for instance, the article by N. Gisin, "Stochastic Quantum Dynamics and Relativity," especially pp. 364, 366.

11. The reason the existence of life is dependent on the weak force is that the weak force is crucially involved in the transmutation of elements, such as the formation of deuterium from protons in the sun. Thus it plays a key role in the sun's being a life-sustaining source of energy. For more information of the role the weak force plays in the existence of life, see Davies, 1982, Rozental, 1988, and Leslie, 1989.

12. The argument that unguided naturalistic evolution cannot explain human consciousness or our capacity for theoretical reasoning has been advocated by both atheists and theists. See, for instance, Paul Davies (1993), Thomas Nagel (1997, pp. 130 - 143), and Alvin Plantinga (1993, chapter 12).

A hypothesis is essentially a guess as to what a situation is. If you are designing something, you will not always know what is going on with the devices and systems that interact with the part you are designing. So you occasionally will have to make a guess. This is a hypothesis.Â Is it a Testing of Hypothesis situation or Statistically Designing an Experiment? There can be testing of one or more hypotheses in a statistically designed experiment. I can perhaps then attempt to answer it. 89 views Â· Answer requested by. The Many-Worlds Theory, Explained. A mind-bending, jargon-free account of the popular interpretation of quantum mechanics. According to the "many worlds" interpretation of quantum mechanics, there may be multiple copies of us living in multiple worlds. Source image: Kelly Sikkema, via Unsplash. By: John Gribbin.Â Meanwhile, I thought I might provide an agnostic overview of one of the more colorful of the hypotheses, the many-worlds, or multiple universes, theory. For overviews of the other five leading interpretations, I point you to my book, â€œSix Impossible Things.â€Â And the existence of all possible worlds may make us more comfortable about the existence of our own world â€¦ which seems to be in some ways a highly improbable one. A hypothesis is a statement that can be tested by scientific research. It usually predicts a relationship between two or more variables.Â There are various ways of phrasing a hypothesis, but all the terms you use should have clear definitions, and the hypothesis should contain: The relevant variables. The specific group being studied. The predicted outcome of the experiment or analysis. 5. Phrase your hypothesis in three ways. To identify the variables, you can write a simple prediction in ifâ€¦then form. The first part of the sentence states the independent variable and the second part states the dependent variable.