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Fine Tuning, Hume's Miracle Test, and Intelligent Design

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Abstract

The fine tuning puzzle is that a number of distinct physical parameters need to take certain precise values for life to exist, values tuned to within 1 in 10^{60}. Hume's "miracle test" says that if someone tells us a miracle has occurred, we should balance the probability it truly occurred against the probability the witness is lying. We argue that the fine tuning evidence of modern science is conceptually the same as a miracle. Physicists have proposed theories which are consistent only if certain parameters and observed data take low-probability values. Hume's miracle test tells us we should compare this situation with the probability the scientists are lying or deceived. Such falsity is highly improbable--- but as improbable as the "miracle"? If we postulate an intelligent designer, the low-probability fit between data and the standard scientific theories is explained. Intelligent design thus makes a falsifiable prediction: that current physics theory will continue to make correct predictions of reality, of which fine-tuning will be a part. Otherwise, scientist fraud or error is more probable than the fine tuning, which implies that over time current scientific theory or data will prove to be false and the coincidences will disappear.

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Introduction

"Fine tuning" refers to the well-known puzzle that various constants in physics need to take certain precise values for life to exist, values tuned to within magnitudes of 1 in 10^{60} or more (as we will explain below). Some deduce from the improbability of the constant taking such a value by chance that an intelligent designer must have created the universe. Intelligent design theory, however, is often criticized by those who take Popper's view of scientific knowledge as lacking falsifiable predictions— occurrences which if observed in the future would lead us to reject the theory.

We will combine the idea of fine tuning with Hume's idea that if someone tells us that a miracle has occurred we should balance the probability it truly did occur against the probability the witness is lying or deceived. We will call this "Hume's miracle test". Part of Hume's motive was to cast doubt on the argument that Christianity's truth is proven by the miracles recounted in the Bible. Our use of the miracle test will have a different result: it provides good reason to believe in intelligent design, whether the designer be the Christian God or someone else. We will argue that a rational observer should believe either (a) An intelligent designer has been at work in the universe, and current scientific data and theory is correct, or (b) There is no intelligent designer, but current scientific data and theory is incorrect. Intelligent design thus rescues science from the accusation of error or falsehood as made by Hume.

We are not philosophers, and we are conscious that we do not present our argument within the fully developed context customary for a philosophy journal. Our aim is to present a simple idea, a different way of looking at the fine-tuning problem, that may be of interest to readers f this journal.

Fine Tuning

Let us start with fine tuning. Many physicists and philosophers have observed oddities in the universe that do not seem capable of explanation within the context of naturalism.[1] The universe has properties which are related to the values of various physical parameters determined by scientific measurement and theory.

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[1] See John D. Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle* (Oxford University Press, Oxford, 1986); Rodney D. Holder, *God, the Multiverse, and Everything: Modern Cosmology and the Argument from Design* (Ashgate Publ., Aldershot and Burlington, VT, 2004; Robin Collins, "Evidence for Fine-Tuning" in *God and Design: The Teleological Argument and Modern Science*, Neil A. Manson, ed. (Routledge, Abingdon, 2003); Martin Rees, *Just Six Numbers: The Deep Forces that Shape the Universe* (Weidenfield and Nicolson, London, 1999); Paul Davies, *The Goldilocks Enigma: Why Is the Universe Just Right for Life?* (Allen Lane, London, 2006).

This paper will not discuss such things as biological fine tuning, evolution, irrreducible complexity, or the origins of life on earth at all.[2] Nor will we contribute anything new to the positive argument that fine tuning implies the existence of God. Rather, we will select three examples to illustrate the variety of fine tuning.

1. The Early Expansion Rate of the Universe. The universe is expanding, something first measured by Edwin Hubble in 1929 in his observation of distant galaxies. Hubble measured a redshift in the spectral lines of galaxies which showed via the already well-known Doppler Effect that they were receding from us with a velocity proportional to their distance, as shown in Figure 1. This implies a single origin for space and time and matter and energy that can be calculated by running time backwards until the size scale of the universe falls to zero. This is the essence of the Big Bang Theory. Einstein's general theory of relativity provides the interpretation that space itself is expanding, carrying galaxies apart, in contrast to the interpretation that galaxies are flying away *through* space. The slope of the best-fit line through the data for all galaxies observed gives the rate of expansion of the universe, yielding an estimate of 13.8 billion years for its age.

[2] We will not address the epistemological arguments based on biology, e.g. Alvin Plantinga's argument that evolution would not generate a brain well-suited to making truthful theories, as opposed to theories useful for reproductive success. Alvin Plantinga (2011) "The Evolutionary Argument against Naturalism," chapter 10 of *Where the Conflict Really Lies: Science, Religion, and Naturalism*, Oxford: Oxford University Press, 2011.

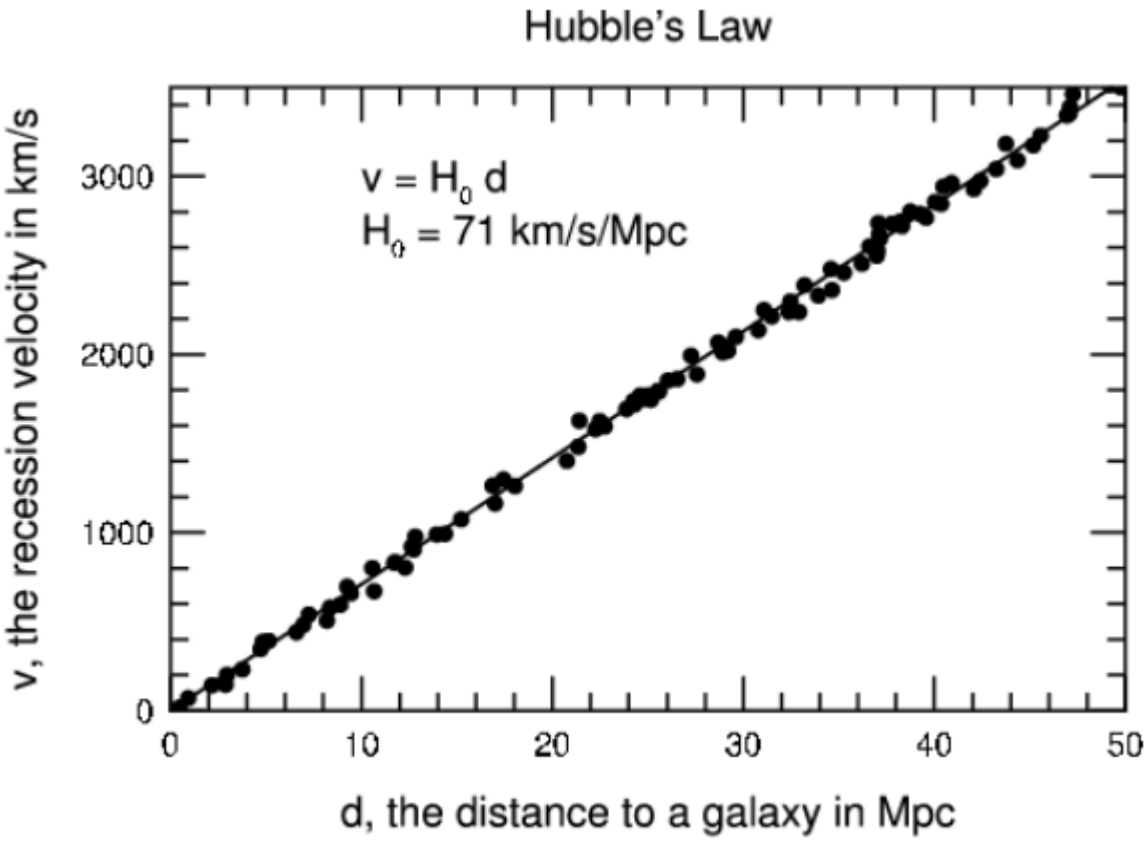

FIGURE 1: HUBBLE'S LAW: RECESSIONAL VELOCITY AS A FUNCTION OF DISTANCE FROM THE EARTH (http://firedrake.bu.edu/CC105/2007/hubble.html)

The universe today has properties which indicate that its initial rate of expansion must have been tuned to a value within narrow limits. If the early universe had expanded too quickly, matter would have spread out too far before gravity had time to coalesce matter into denser regions to form galaxies. On the other hand, if the expansion rate had been too slow, gravity would have re-collapsed the universe into a mess of black holes. In either case, life (and even stars and galaxies!) would not be possible.

How finely tuned did the early expansion rate need to be? Scientists calculate that the expansion rate had to be tuned to within 1 part in 10^{60},[3] meaning that it could not have deviated by more than 1 part in a quadrillion times itself 4 times. To be sure, one can construct alternative theories. The theory of cosmological inflation, proposed by Alan Guth in 1980, says that very early in the history of the universe an ultra-fast expansion briefly occurred, which

[3] See Hugh Ross, *Why the Universe Is the Way It Is*, p. 35; Rodney Holder, *Big Bang, Big God: A Universe Designed for Life?* (Lion Books, Oxford, 2013) p. 88; Peter Coles and George F. R. Ellis, *Is the Universe Open or Closed? The Density of Matter in the Universe* (Cambridge University Press, Cambridge, 1997); Peter Coles, ed., *The Routledge Critical Dictionary of the New Cosmology* (Routledge, New York, 1998).

eliminates the need for a fine-tuned initial expansion rate.[4] The fine tuning shows up in a different place, though: the conditions for inflation to start and stop at the right time and to have the right order of magnitude introduce new fine-tuning constraints.[5] A recent analysis of inflation and the "fine-tuning problems" of the big bang model concludes it cannot be said unproblematically that inflation solves the model's fine-tuning problems. [C. D. McCoy, "Does inflation solve the hot big bang model's fine-tuning problems?" Studies in History and Philosophy of Modern Physics, 51 (2015) 23-36.]

2. The Amount of Dark Energy Needed To Explain Expansion Rate Acceleration. It seems the expansion rate of the universe is not constant, but accelerating. The rate is controlled by two competing factors: the force of gravity acting on the overall mass of the universe, which acts to slow the expansion, and the repulsive effect of dark energy, a "space energy" postulated to explain the observed acceleration in the universe's expansion rate by increasing its effect as the size of the universe increases. The theory of dark energy and the conclusion from data that the expansion is accelerating are new, but have become the consensus among physicists.[6] In 2011, the Nobel Prize in Physics was awarded to Perlmutter, Schmidt, and Riess for discovering the accelerating expansion of the Universe.

In order to explain the acceleration within the context of existing theories of physics, it became apparent that the strength of the dark energy had to be fine-tuned to 1 part in 10^{120}.[7] As Davies remarks (p. 149) "The cliché that 'life is balanced on a knife-edge' is a staggering understatement in this case."

3. Low Entropy at the Big Bang. Sir Roger Penrose (1999, p. 726) has drawn attention to the fact that our universe began with matter and energy very evenly distributed, which can be described as a state of "absurdly low entropy." The 2nd Law of Thermodynamics states that the entropy of the universe must (and does) increase with time, and the initial low entropy of our universe allows the 2nd Law to function. To determine just how special the initial conditions of the big bang were, Penrose has calculated that out of all possibilities, the chance of obtaining a universe with initial conditions as special as ours is only 1 part in 10 billion multiplied by itself

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[4]Alan H. Guth, The Inflationary Universe: The Quest for a New Theory of Cosmic Origins, (London, Jonathan Cape, 1997). See also Coles and Ellis, and Coles citations, above.

[5] Holder, p. 120-23; Barrow and Tipler, pp. 435-438.

[6] See Adam G. Riess et al. (Supernova Search Team) (1998) "Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant". *Astronomical Journal* 116 (3): 1009–38; S. Perlmutter et al. (The Supernova Cosmology Project) (1999). "Measurements of Omega and Lambda from 42 High Redshift Supernovae". *Astrophysical Journal* 517 (2): 565–86.

[7] Davies, p. 149; Holder, pp. 91-92.

123 times! Missing the precise conditions specified would lead to a completely uninhabitable universe.

Hume's Miracle Test

In Chapter 10, "On Miracles," of his *An Enquiry into Human Understanding,* Hume lays out his main proposition as

> That no testimony is sufficient to establish a miracle, unless the testimony be of such a kind, that its falsehood would be more miraculous, than the fact, which it endeavours to establish: And even in that case there is a mutual destruction of arguments, and the superior only gives us an assurance suitable to that degree of force, which remains, after deducting the inferior.

This is what we call Hume's miracle test. His first application is bringing a dead man to life.

> When any one tells me, that he saw a dead man restored to life, I immediately consider with myself, whether it be more probable, that this person should either deceive or be deceived, or that the fact, which he relates, should really have happened. I weigh the one miracle against the other; and according to the superiority, which I discover, I pronounce my decision, and always reject the greater miracle.

The miracle test is the focus of an entire literature in philosophy, from John Earman's *Hume's Abject Failure* to Robert Fogelin's *A Defense of Hume on Miracles*.[8] Hume's discussion is what one would expect of an 18th century work, elegantly written but less precise than modern scholarship, exactly the optimum for a work to be seminal but not conclusive. The miracle test may not be original with Hume, it may be obvious to some people, and it may not be as strongly opposed to belief in miracles as he says, but it is a useful aid to thinking, whatever its efficacy in the context of religion. Rather than just saying, "That event is so improbable it can't have happened," Hume proposes an all-purpose alternative explanation, "It is more likely that you are lying or deceived than that this happened." Lacking any alternative explanation, even improbable events have to be accepted. Hume provides us with a standard alternative. Yet that alternative is not a showstopper: in some situations, the alternative of the unreliable observer is even more improbable than the miracle. Indeed, William Paley implicitly is responding to Hume when he argues at length for the plausibility of the apostles' testimony about the

[8]John Earman (2000) *Hume's Abject Failure*. Robert Fogelin (2003) *A Defense of Hume on Miracles*.

Resurrection, arguing, for example, that they had little to gain and much to lose by persisting in asserting its truth.[9]

Hume's intent was to cast doubt on Christianity, but the principle is applicable and useful independent of that. Let us continue with the example of resurrection. Suppose you read in the April 6 *The Wall Street Journal* a story about a man who after having been buried for two weeks was found after the grave was reopened to be alive and normal. With what probability do you think people are raised from the dead in that way? You probably will pick a very low number--- say, 1 in 100 billion. With what probability do you think *The Wall Street Journal* would print a joke article? This, too, will be a very low number--- say, 1 in 100,000--- since the *Journal* is a serious financial newspaper. But it's possible that the editors decided to be quirky, or a hacker was making fun of *The Journal,* or an April Fool's Day article intended for April 1 was mis-scheduled. Accepting the alternative with the higher probability, you would disbelieve the article. More precisely, the probability you'd assign to the story being true via Bayesian updating would still be miniscule, even though perhaps it would double from 1 in 50 billion to one in 100 billion.[10]

Hume's resurrection example is binary. The man rose from the dead, or he did not. Also, it is an event completely inconsistent with conventional natural law. In cosmology, what we will find is events that are consistent with natural laws but improbable. Suppose the *Journal* article is about an ESP study in which a researcher says that Mr. Psychic induced a die to come up "6" 20 times in a row. This pattern of outcomes is, of course, just as likely as any other permutation. A random die would produce this accuracy with probability $(1/6)^{20} = 2.7^{-16}$, however--- about 3 in 10 quadrillion. The reader, like the authors, would have to use a calculator to come up with this exact probability, but even without that he would undoubtedly put very low probability on the outcome. He would not make the argument that the result probably occurred by chance. Should he believe, then, that Mr. Psychic has special powers? The miracle test says that he should compare the likelihood that Mr. Psychic really has special powers with the likelihood that lying or trickery is being used by Mr. Psychic, the researcher, or the reporter.

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[9] William Paley (1794) *Evidences of Christianity (*not to be confused with his 1802 *Natural Theology or Evidences of the Existence and Attributes of the Deity)*.

[10] We are not using Hume's definition of a "miracle". He says, "There must, therefore, be a uniform experience against every miraculous event, otherwise the event would not merit that appellation." We assign low probabilities to some events outside our uniform experience, but we assign high probability to others (e.g., if one of us authors meets a Manxman some day, we would not call it miraculous, despite never having met one). And we are ignoring a second possible requirement for something to be a miracle, that there have been divine intervention (see Harrison [1995] and Earman [2000]), since in our context that would be begging the question. The genius of the miracle test not restricted to religious miracles; it is the idea of questioning premises by comparing the probability of the miracle to the probability of false report.

The miracle test applies to beliefs by anybody, not just experts. Each person has to decide for himself whether to believe in the miracle. He can collect additional information by asking experts or googling, but at a given moment he needs to use what information he has. That is important in the context of fine tuning because the details of the theory and the data-collection techniques are understood only by experts, so the rest of us are faced with the decision of how far to trust the experts.

Fine Tuning as a Miracle

A "miracle" is an event highly improbable according to our prior beliefs. We call events entirely opposite to our experience and belief about how the world works "miracles" if we assign very low probability to those particular experiences and beliefs being wrong. What is low probability is a ticklish matter, as Sober (2012) explains in his article on coincidences. Science deals with low-probability events all the time. The probability a given uranium atom will decay in a given second is small, yet we are not surprised to find an atom that has decayed. In terms of the exact permutation, to roll a random sequence of numbers, such as 363452 with six dice is no more probable than to roll 666666. We are surprised by the latter because what we are really thinking of is "A series of rolls with no pattern" versus "A series of rolls in which every roll adheres to a pattern." Our surprise is converted to suspicion if we are playing a game in which 666666 wins but every other roll loses.

Fine tuning is like the game in which 666666 wins rather than the detection of an atom that has decayed. Our theory says that parameters have to take a very special value to explain our world. Some fine-tuning parameters are measured to be their special value; others are constants that must be assigned a special value for the theory to be consistent. In both cases, the observer finds it surprising that the parameter would take that special value.

To be sure, one might argue, with Manson (2000) and McGrew, McGrew and Vestrup (2001) that to say a range of values has low probability is incoherent because the probability of the values of an arbitrarily chosen number is ill-defined. Can we say that values between 5.00 and 5.01 have low probability and values between 5 and 20 do not? Not if the numbers are chosen according to a uniform distribution between 0 and 10 million. In that case, both intervals have extremely low probability and should equally surprise us. This is the "coarse-tuning" objection to fine-tuning: that it proves too much, a reductio ad absurdum. In the case of dice rolls, we know the probability of each possible roll. Since physics constants do not come with a support or a distribution, how can someone form a probability?

Koperski (2005) discusses the problem in detail, explaining how it related to measure theory. A "measure" is a definition of volume in a space; e.g, standard distance in one-dimensional Euclidean space. An example of an unintuitive measure from Sklar (1993, p.101) is that a measure that makes the intervals [0, .9] and [.9, 1] the same size.[11] Much of his

[11] L. Sklar (1993) *Physics and Chance*, Cambridge: Cambridge University Press.

discussion applies to determining whether an event has literally zero probability (measure zero), but the same problems apply to determining the probability of a finite interval. He suggests that one way to address the problem is to use a mathematical measure based that is itself based on constants in physics, e.g. the cosmological constant and energy density measure constructed by Ellis, Kirchner, and Stoeger (2004) combined with a uniform distribution, an improper Bayesian prior.[12] Thus, it is possible to construct a coherent probability--- but then the problem is to justify it as not being arbitrary.

Another approach, which is sufficient for us in our context, is to use a subjectivist Bayesian approach. Under this approach, the unknown distribution of possible values of the constant is a subjective belief of some single person--- yourself being an obvious starting point. Each person has some belief, however uncertain, about the probabilities of different values. Based on those priors, the person is surprised to one degree or another if the value turns out to be in a particular interval. We assert that everyone who can understand the problem would be surprised by an expansion rate that had to lie within 1 part in 10^{60} of some value X, even though each person would have a somewhat different subjective prior.

Note that in saying this, we have relied on the proposed value X itself. The theory actually picks a particular value of X, but we believe that however big or small X might be chosen, the observer would think the probability low that the value would lie within 1 part in 10^{60} of X. This assertion that human minds use a normalization to X allows us to escape the problem of coarse tuning, since the size of interval required for surprise rises with X. What remains is the question of how small the fine tuning interval has to be for someone to say it is low-probability, and how exactly to specify the size of that probability. We will thus make a second assertion: that when a person thinks of possible values for X that he think are serious suggestions, he limits the possibilities to, say, the interval [X- 10^{10}X, X + 10^{10} X]. Or, to put it differently, the person would not believe that X falling within the interval [X- 10^{10}X, X + 10^{10} X] was a low-probability event.

When someone describes seeing a miracle, he says that something highly improbable has happened, so improbable as to require more explanation than random chance. When someone reports astronomical observations and uses a finely tuned theory to explain them, he also says that something highly improbable happened and is similarly dissatisfied with chance as an explanation. Fine-tuning is thus conceptually like a miracle: a low-probability event that leaves the listener dissatisfied.

For our purposes, however, it is perhaps unnecessary to define what is a low-probability event. That would necessary if we were to argue for the rejection of scientific theory without proceeding to consider alternative explanations, but even the full intelligent design argument does not do that, though naive versions do jump from the event being low-probability to the existence of a designer. Rather, what matters is relative probabilities. The full argument is that fine tuning by randomness has a lower probability than fine tuning by a designer, which relies

[12] G. F. R. Ellis, U. Kirchner and W. R. Stoeger (2004)"Multiverses and Physical Cosmology" *Mon. Not. R. Astron. Soc.* 347: 921-936.

on one's degree of belief in God or intelligent space aliens. Here, we introduce Hume's miracle test to suggest the alternatives.

The miracle test tells us that in evaluating observations and theories that seem improbable, we must include in our evaluation the probability the scientists are lying or deceived. Would Riess with his team of 19 co-authors and Perlmutter with his team of 32 lie about the accelerating expansion of the universe? The claim did yield them a Nobel Prize, after all. To be sure, scientists rarely lie, and we do not know of any example of a coordinated effort by a group of scientists in free countries to commit fraud in support of a theory (though the ClimateGate document release does make one wonder).[13] And besides the 53 co-authors of the Riess and Perlmutter articles, the conspiracy would have to include anyone who has tried to replicate their work. If such a fraud were to occur, however, would we call it miraculous? As conspiracy theories go (admittedly not a high bar) it involves relatively low stakes and a small number of people, since the topic is esoteric. Would we say its probability is below the 1 part in 10^{60} needed to fine tune the universe's early expansion rate? If, in addition, we allow for the more likely possibility that the scientists are simply mistaken, the Humean alternative becomes even more attractive than random probability. We should adopt the fraud-or-mistake theory as the lesser of two evils.[14] We should reject observations and theory that purports to imply fine tuning.

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13 A typical email from Phil Jones, a leading researcher in the field, said, "Any work we have done in the past is done on the back of the research grants we get – and has to be well hidden. I've discussed this with the main funder (U.S. Dept of Energy) in the past and they are happy about not releasing the original station data." James Taylor, *"Climategate 2.0: New E-Mails Rock The Global Warming Debate*," *Forbes* (11/23/2011). Dr. Jones tells us this is a standard attitude in climate science, saying, " 'Hidden' refers here to some of the work on data collection and management. This is a common issue in some areas of climate research and refers to issues of an operational nature and research aspects. An obvious example is updating earlier data sets within a new project. Most funders are fully aware that this is common practice." Phil Jones (2011) "Cherry-Picked Phrases Explained," University of East Anglia, http://www.uea.ac.uk/mac/comm/media/press/CRUstatements/rebuttalsandcorrections/phrasesexplained (November 23, 2011). Note, however, that the theory of global warming is quite plausible, whatever the ethics of some of its proponents, and Hume's miracle test cannot be used to rule out a plausible event even if one thinks it very likely that the witness would like it if the event had not taken place.

[14] False theories have in the past often proved highly effective at making true predictions. The converse is Eugene Wigner's "the nightmare of the theorist" as explained in Eugene Wigner (1960) "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," in *Communications in Pure and Applied Mathematics*, 13: 1-14 (February 1960). "...the fact that some of the theories which we know to be false give such amazingly accurate results is an adverse factor. Had we somewhat less knowledge, the group of phenomena which these "false" theories explain would appear to us to be large enough to "prove" these theories. However, these theories are considered to be "false" by us just for the reason that they are, in ultimate analysis, incompatible with more encompassing pictures and, if sufficiently many such false theories are discovered, they are bound to prove also to be in conflict with each other. Similarly, it is possible that the theories, which we consider to be "proved" by a number of numerical

How the Miracle Test Defeats the Anthropic Principle

The anthropic principle has been stated in different ways. Brandon Carter's 1974 weak anthropic principle is, "We must be prepared to take account of the fact that our location in the universe is necessarily privileged to the extent of being compatible with our existence as observers" (p. 3228*check page number). His example is that we can estimate the age of the universe using the fact that it must be old enough for stars of the Sun's type to develop. Carter's strong anthropic principle says, "The universe (and hence the fundamental parameters on which it depends) must be such as to admit the creation of observers within it at some stage" (p. 3229*check page number). Thus, for any theory to be valid, the values of physical constants must be calculated to allow for the existence of life. The two principles can be seen as saying that we should predict that values of as-yet unobserved variables must take levels compatible with one of our basic pieces of data--- our existence. These are useful principles, but they do not explain fine tuning. Rather, they are the source of fine tuning, by requiring theories to assign exactly the values to variables that are required for life.

Other scholars state the principles differently. Barrow & Tipler's 1986 weak anthropic principle says, "The observed values of all physical and cosmological quantities are not equally probable but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirements that the Universe be old enough for it to have already done so." Their strong anthropic principle says, "the Universe must have those properties which allow life to develop within it at some stage in its history" (pp. 16, 21). Stated this way, the anthropic principle becomes a potential explanation for fine tuning: the finely tuned values are not the result of chance but of necessity.

If observers could not observe a universe not fine tuned for life, then our observations of the universe are a biased sample. They are confined to a universe that is fine tuned, and we would draw false deductions from our sample. If life has a 1 in a million chance of arising on a given world, and the outcome is that 1 of the 1 million existing worlds has life, then if its inhabitants ignore that fact, life will seem miraculous despite being quite probable. It does not follow that something is miraculous just because it is rare.[15] The existence of fine tuning has to

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agreements which appears to be large enough for us, are false because they are in conflict with a possible more encompassing theory which is beyond our means of discovery. If this were true, we would have to expect conflicts between our theories as soon as their number grows beyond a certain point and as soon as they cover a sufficiently large number of groups of phenomena. In contrast to the article of faith of the theoretical physicist mentioned before, this is the nightmare of the theorist."

[15] The "multiverse" idea addresses this. It hypothesizes that there exist multiple universes. If there are a million universes, it is not surprising that one of them has 1-in-a-million-probability properties. Such eminent philosophers as John Leslie, Derek Parfit, J. Smart, and Peter van Inwagen have favored the idea of the multiverse. See John Leslie (1989) *Universes,* London: Routledge; Derek Parfit (1998) "Why

be considered in light of all data, not just local data. A supernatural spirit looking down would not find it surprising that one planet had life, or that any particular planet was the one with life. If, however, the chance of life arising has a 1 in a trillion probability, would it be correct for the inhabitants and the supernatural observer to believe life is miraculous?

It is misleading to consider one decision in isolation, however. What is central here is not the conclusion that fine tuning is miraculous but the process by which we form our beliefs. It is rational to think that because something has small probability and no apparent explanation, the explanation must be some new theory rather than chance. Put this way, the answer is clear. If an observer in 1850 were to observe a rock emitting energy continually for three months without any input of energy from outside or change in its temperature, shape, or position, he could believe that this was a case of measurement error. Or, he could reject the theory of conservation of energy in its 1850 form and postulate some new energy source (radiation, of course--- the rock being uranium ore). On occasion, this will mislead us, and if we know the distribution of the random process, classical statistics tells us how often.

Consider now the people on the lone planet with life. They have a choice between thinking their world's exceptionalism is due to chance, or to some hitherto unknown explanation, just as with the radiating rock. They should use the same decision process they do for all their decisions: if an event has sufficiently low probability, look for a new explanation. It does not change things that if life on a planet truly is random, with certainty the observers on that planet will be mistaken in using this thought process. If we condition on the conclusion being wrong, any thought process will look bad.

Hume addresses the problem of the reasonable mistake, though in the context of mistaken *dis*belief in miracles rather than mistaken belief. He writes of an Indian prince who rejected the idea of snow when he was told of it.[16]

> The Indian prince, who refused to believe the first relations concerning the effects of frost, reasoned justly; and it naturally required very strong testimony to engage his assent to facts, that arose from a state of nature, with which he was unacquainted, and which bore so little analogy to those events, of which he had had constant and uniform experience. Though they were not contrary to his experience, they were not conformable to it.

Anything? Why This?" *London Review of Books,* Jan 22, pp. 24–27; J. J. C. Smart (1989) *Our Place in the Universe: A Metaphysical Discussion,* Oxford: Blackwell; Peter van Inwagen (1993) *Metaphysics,* Colorado: Westview Press. We do not think the multiverse really addresses the problem of why one particular universe has a specific property, particularly if we have no evidence that the other universes exist. That something improbable happens here is not evidence that another universe exists; see Roger White (2000) "Fine Tuning and Multiple Universes," *Nous* 34: 260-276.

[16] This example is not original with Hume. Locke used it earlier, as shown in the primary sources at the end of Earman (2000).

We agree that the Indian prince was rational. When someone came to him and said that in cold countries water often takes a solid form and turns into beautiful but fragile crystals, he was right to be skeptical. He compared the probability that snow really existed and had been seen by the speaker with the probability that the speaker was telling a lie in the hopes of being interesting and seeming knowledgeable. Even if the prince thought to himself, "In a situation where the speaker is telling the truth, this skepticism will lead me to the wrong conclusion," he should just accept that a certain probability of false negatives is inevitable in optimal decision making. He must choose some level of skepticism, and the higher the degree, the smaller the chance of false positives but the bigger the chance of false negatives.[17] In the same way, the anthropic principle just says that if the amazingness of fine tuning is illusory, we shouldn't be amazed at fine tuning, but it doesn't consider that if the amazingness of fine tuning is valid we *should* be amazed.

A second reason to reject the anthropic principle, however, and more novel, is the miracle test itself. Recall that the anthropic principle's explanation for fine tuning is that we have a nonrandom sample. Its explanation for fine tuning is that though it is improbable, the improbable sometimes happens and when it does, thinking about overall probabilities is misleading. The miracle test provides an alternative explanation. It says that the improbability of fine tuning can be explained by the falsehood of the science leading us to assign a low probability to the parameters involved in fine tuning. Then we have, on the one hand, the possibility that we are in the one-in-a-million world, but on the other hand the possibility that the science is false. People on the planet should confront the theory that says life has a one in a million probability against the theory that says that all million planets have life, but there is a five in a million chance that scientists trying to explain life will come up with a false 1-in-a-million theory. Of course, if fine tuning had as high a probability as one in a million, the anthropic principle might dominate, since perhaps the probability of mistake is no higher than 5 in a billion, not 5 in a million. But given the actual much lower probabilities of getting the fine tuning right by random chance, a more likely explanation is that current science is wrong.[18] We are much more likely to be in a universe with bad data or theory than in one with true and random fine tuning. The Big Bang Theory should be rejected, just as the Steady State model, or

[17] Statisticians, following the tradition of Neymann and Pearson, put this as a tradeoff between Type I and Type II error. We prefer the false negative and false positive terminology, because of the the old economic joke about Type III error: mixing up which one is Type I and which one is Type II.

[18] This knocks out the idea of the multiverse as well, since the probability within that theory of our being in a universe suitable for life is much lower than the probability that the scientists who propose the theory in our particular are mistaken or deceived. The multiverse has other problems; for example, if anything can happen because there are sufficient universes, then that anything would include a multiverse-destroying machine which would have destroyed the multiverse, eliminating the premise of the theory. That does depend on the precise phrasing of the premise of what "anything'' includes.

Continuous Creation,[19] was--- though, admittedly, we may have nothing satisfactory to put in its place and as economist Paul Samuelson said in 1956, "It takes a theory to kill theory; facts can only dent the theorist's hide."[20]

Intelligent Design to the Rescue

So far we have a depressing judgment of current cosmology. It seems we should reject its fundamentals. The Big Bang requires such incredible fine tuning that it's more likely scientists have the whole thing wrong or made up the data, perhaps trying to wrestle more dollars of research grants from the particle physicists who confess openly to not having detected quarks.

Intelligent design comes to the rescue. It explains the data regarding the physical constants without casting doubt on current physics theory. If the Christian God or someone else designed the universe, it is not surprising that it is fine-tuned, any more than that a bridge has balanced lines of force just sufficient to hold it up. We do have to add a hypothesis to existing theory, but that is always true of theories after new observations upset their plausibility.[21]

Our choice is thus not between intelligent design and random coincidence, but between intelligent design and current scientific theory. Without the feature of a designer, the finely-tuned fit to the data of several standard scientific theories is less probable than that the leaders in those subfields are lying or deceived. Intelligent design makes a falsifiable prediction: that current physics theory will continue to make correct predictions of reality, of which fine-tuning will be a part. The alternative, scientist fraud or error, implies that with time current scientific theory will prove to be in error.

It is hard to assign probabilities without having a set of possibilities and a distribution with which to choose a subset of them, of course. The exact values of the finely tuned constants is

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[19] Continuous creation is a competing cosmological theory associated with the name of Fred Hoyle that fell into disfavor because it could not explain the universe's background radiation detected in 1963 by Arno Penzias and Robert Wilson, radiation predicted by the Big Bang theory. For an accessible sketch of the history, see American Institute of Physics, "Big Bang or Steady State?" http://www.aip.org/history/cosmology/ideas/bigbang.htm (2014).

[20] Paul A. Samuelson (1956) on p. 323 of *The Impact of the Union: Eight Economic Theorists Evaluate the Labor Union Movement* by David McCord Wright; John Maurice Clark; Gottfried Haberler; Frank H. Knight; Kenneth E. Boulding; Edward H. Chamberlin; Milton Friedman; David McCord Wright; Paul A. Samuelson, New York: Kelley & Millman (1956).

[21] We consider the "Matrix Simulation" theory to be a variant of intelligent design. In that theory, our universe is not real, just a clever simulation designed by a powerful outsider to fool us. The difference from standard intelligent design is the idea that the designer's imperfection or laziness is responsible for fine tuning: he has had to patch his simulation up with a number of implausible coincidences and thus leave traces. See Davies (2006, p.202); Nick Bostrom, "The Simulation Argument: Why the Probability You Are Living in a Matrix Is Quite High," *Times Higher Education Supplement* (May 16, 2003); Nick Bostrom, "Are You Living in a Computer Simulation," *Philosophical Quarterly, 53: 243-xxx* (2003). In standard intelligent design theory,the designer can leave coincidences behind intentionally, so as to hint at his existence. The difference is not important for this paper.

not relevant for our argument. We have described above 3 examples of cosmological fine-tuning: the initial expansion rate of the universe (or the conditions for cosmological inflation); the strength of the dark energy parameter; and the initial value of the conditions of our universe which lead to the 2nd Law of Thermodynamics. Let any one of these parameters be referred to as K, and let the range of values it may take in order for life to exist lie between X and Y. Pick, according to your own knowledge and reasoning ability but using your honest best efforts, the possible values which K could take, and the probabilities of those values. Now compute the probability that K lies between X and Y given that no intelligent designer is involved. It's very low— 1 in 10^{120}, for example. The probability it lies between X and Y if an intelligent designer exists is one. But we must multiply this probability of one times the probability the intelligent designer himself exists. This estimate will vary drastically between individuals. You may not choose 0 or 1--- or rather, if you do, you are not able to think rationally on this subject. If you say the probability of an intelligent designer is zero, then even if God appeared in the sky with a legion of angels and raised your ancestors from the dead, you would refuse to believe it. Indeed, you would be saying that no amount of evidence would persuade you. Those who put probability 1 on an intelligent designer's existence are similarly unreasonable. They are saying that even if God descended from Heaven and told them He did not create the universe they would refuse to believe Him.

Let's take as an example someone who is an atheist, a disbeliever in alien designer races, and so forth, and who puts the probability of an intelligent designer at 1 in a million. If this probability is greater than the probability he assigns to scientist fraud or mistake, then he should retain his belief in the Big Bang as currently formulated, but add to it the premise of an intelligent designer to explain fine tuning.

There is an easy, but fallacious, reply to this argument. It is that our exercise of having you choose probabilities such that the value of K is in interval [X,Y] is irrelevant, because we know the probability is one. After the value of K is chosen, that value has probability 1 and all of the other values have probability zero.

Therein lies the fallacy. We do not know that the value of K lies within [X,Y]. What we know is that all the physics books tell us that. But they might be mistaken, or they might have falsified the data. The probability is very low, of course. But using the miracle test, we must figure out *how* low. Here, the miracle is that the value of K lies in [X,Y] . We have a choice between believing that K indeed lies in [X,Y] but it is just a coincidence, on the one hand, and believing that the physicists who calculated the value made a mistake, on the other. Both are low probability events, but which is lower?

The low probability of both the constants' coincidence and the possible error or deception of the scientists suggests that you can keep only two of these three beliefs:

1. There is no designer. (This implies that scientific theory is wrong if the data is correct, or that the data is wrong if the scientific theory is correct.)

2. The data is correct. (This implies that scientific theory is wrong if there is no designer, or that there is a designer if the scientific theory is correct.)

3. The theory is correct. (This implies a miracle of design, meaning God exists, if the data is correct, or that the data is wrong if there is no designer.)

It is easy to be misled in reasoning about events with low prior probability. Sober (2012) uses the example of two individuals whose genes match at 13 rare loci. The probability of this happening if the two are unrelated is 6.5×10^{-38}, while probability if they were siblings would be 7.7×10^{-32}. It is very improbable that the two are siblings who have such a close match, but that has high probability compared to them being non-siblings who match. Likelihood depends on what explanations are available, not just on the probability of a single explanation.

It is of course thus possible to retain belief 1. Someone with a sufficiently low prior knowledge on the existence of God or some other designer would do so. He would put more faith in the nonexistence of a designer, though, than in the basic correctness of scientific observations or theory. He would adopt a conspiracy theory of science or believe that something is fundamentally mistaken in how scientists view the world. But this would not just be the result of his belief as to the probability of a designer; however low he might put that probability, what is crucial is that he put the probability of science being mistaken higher.

A falsifiable prediction from intelligent design: No paradigm shift in the next century

One criticism made of the idea of intelligent design is "It has no falsifiable predictions".[22] This refers to the logical positivist view of what constitutes a scientific theory. The general idea of the 1930's philosophical school of logical positivism is that a huge amount of confusion and disagreement in human knowledge can be eliminated by reducing words down to what they imply about physical observations. For example, the question of whether God is omnipotent is meaningless, because there is no way humans could distinguish between a God who can move rocks on Pluto and a God who can do everything else in the universe except that. Thus, what philosophers or theologians should really be arguing about is whether God is capable of doing

[22] See National Academy of Sciences (1999) *Science and Creationism: A View from the National Academy of Sciences,* Second Edition (1999) p. 25, cited in Michael Behe, "The Intelligent Design Hypothesis" in *God and Design: The Teleological Argument and Modern Science,* Neil A. Manson, ed. (Routledge, Abingdon, 2003).

anything humans can observe as His actions. Popper applied this to science. He said that for a theory to have meaning, it must make predictions about future events (which includes measurements from experiments), and must make falsifiable predictions--- predictions that could turn out to be wrong.

Popper's theory is now unpopular among philosophers for various reasons. It has difficulties explaining theories of historical observations, ignores Occam's Razor, omits consideration of a theory's "beauty", ignores the value of confirmatory evidence, has trouble with probabilistic evidence, and so forth. Everyone would say, however, that Popper contributed to how we think about science, and that it is useful to look for falsifiable predictions--- especially for novice scholars, who can easily entangle themselves in complex meaningless theory, whether verbal or mathematical. And many economists and scientists, if not philosophers, end their meta-scientific thinking once they've learned about Popper.

What about intelligent design? There are certainly falsifiable predictions, but the easiest to conceive of are those which illustrate another problem with the idea: false negatives in testing the alternative hypothesis ("Type II error" or "low power", in statistical language). The theory of Intelligent design by a truthful God would be falsified, for example, if in 2020 we observed a message appear in block letters on the moon: "I am God, and I did not design this universe." Even according to theories of truthful intelligent designers, however, this event is unlikely to occur, so while its occurrence would definitely falsify, its non-occurrence is trivial confirmation.

The earlier discussion in this paper, however, gives us a more definite, if still probabilistic, falsifiable prediction. The theory of intelligent design plus current physics roughly implies that current physics will not be discredited within the next century: there will be no paradigm shift that eliminates the evidence of fine tuning. The theory that there is no intelligent designer, on the other hand, implies that current physics will be replaced by something that eliminates the fine-tuning "problem", because it requires an absurdly high level of coincidence.

This sounds unfairly biased in favor of intelligent design. Of course, there is always a bias towards truth, and whether that is fair is in the eyes of the beholder. But in at least one historical example, fundamentalist Christians did find their prediction falsified--- and existing physics *was* discredited.

This example is the story of Lord Kelvin's 1862 argument for limiting the age of the earth. Darwin had recently published his theory of evolution. The theory of evolution requires long periods of time for natural selection to result in the change of animal populations. Kelvin noted that the earth could well be older than the 6,000 years some people proposed, but not old enough for evolution to be a viable theory. The problem was that under the standard theory of physics, even if the initial heat of the earth were at the upper level of any estimate physicists found conceivable, the time taken for that heat to dissipate and the earth to grow cold would

be much smaller than the amount of time needed for evolution. Thus, either physics was wrong, or Darwin was wrong, or both were wrong.[23]

The physics of that time was wrong. Kelvin didn't know about radioactive decay. It is only because of energy from radioactive elements that the earth did not grow cold billions of years ago. Another way to look at Kelvin's argument is that it seemed that either his controversial contemporary Darwin was wrong, or the entire physics community was wrong---- and it was the obscure naturalist who ended up winning that fight. As it has turned out, though, the old age of the earth provides less support for Darwin than might have been imagined. The problem is that while the Earth may be 4.5 billion years old, the time between when geological forces let it become habitable (about 3.8 billion years ago) and when the earliest evidence of life appears (again, about 3.8 billion years ago) is remarkably short.[24] So perhaps Kelvin has the last laugh.

Thus, we should take seriously the prediction that modern physics is wrong--- in the sense of being deficient in some key theories that are completely accepted, but are wrong in major details.

We anticipate that some people will call this a "God of the Gaps" argument. They would say that just because current scientific theory does a poor job in explaining certain things is unimportant because we can expect science to fill those gaps and steadily diminish their number. That, of course, does not affect the claim that current physics is wildly improbably and should not be believed, but it does affect which of the two future events will occur: (1) current physics will be replaced, vs. (2) current physics will be retained, but with intelligent design added to it. History has not worked out as predicted by the God of the Gaps argument, however, either in biology or physics.[25] The theory of evolution, despite success in explaining variation among species, explains the origins of life no better now than it did in Darwin's day despite the enormous amount of work that has gone into trying to make it do so. Indeed, this work has made natural selection even more problematic as an explanation, because in Darwin's day evolution did not have to explain how so complicated a molecule as DNA, now known to be the basis of all life, could result from the random interaction of gas, water, and rock. As for physics: the three fine tuning examples we described above are all relatively new, all dating from after 1986. The question of how fast the number of gaps being opened in physics has increased relative to the number being filled requires a separate article, but we can

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[23] The story is told in David Lindley, *Degrees Kelvin* (Joseph Henry Press, 2004), pp 164-214. Kelvin's paper is: Sir William Thomson (Lord Kelvin) "On the Age of the Sun's Heat," *Macmillan's Magazine*, 5: 288-293 (March 5, 1862), http://zapatopi.net/kelvin/papers/on_the_age_of_the_suns_heat.html#fn2b.

[24] Jeffrey Bennett, Megan Donahue, Nicholas Schneider, Mark Voit, *The Cosmic Perspective: The Solar System*, 7th ed. (Pearson, San Francisco, 2014) pp. 698-99; Fazale Rana and Hugh Ross, *Origins of Life,* NavPress, Colorado Springs, 2004, chapter 5.

say that we know of no major work on fine tuning older than 1974, nor any examples of fine-tuning "gaps" being filled.[26] The trend shows an increasing number of examples of fine-tuning as research progresses. "The more accurately and extensively astronomers measure the universe, the more finely tuned they discover it to be."[27]

Concluding remarks

Hume's miracle test reminds us to question our premises. If the data is improbable, maybe it's false. His original application was to cast doubt on claims of divine miracles,.Hume attempted to short-circuit the claims by bringing up the possibility that the miracles didn't happen. The miracle test says that if the probability of the miracle being a deception is much greater than the probability that it occurred supernaturally, one should conclude that it was a deception. The miracle test is a genuine test, however, not a conclusory argument. William Paley responded to Hume's challenge in 1794 with his *Evidences of Christianity*, for example, which took the challenge seriously but argued that current experience gives no guide to the probability of ancient miracles: that mainstream protestant doctrine, if not Roman Catholic, holds that biblical miracles did occur in the past but not in the present, and that the evidence is as strong for the Bible's miracles as for other ancient events.[28] Since the miracle test has general applicability, however, we can apply it to other low-probability events. Cosmological fine tuning is one such application. The probability that the parameters take the value required for the theory to allow life to exist is vanishingly small. To be sure, if they are what they are, then one can apply the anthropic principle argument to say that any observer would observe only those parameters. We can also apply the miracle test, though, and not admit too quickly that the parameter values are what they are--- or that the theory requiring those values is sound. We must ask whether the astronomical observations or the physics theory involved might not be forged, or, more likely, mistaken, despite its general acceptance. Intelligent design comes to the rescue of science at this point. It explains the data regarding the physical constants without casting doubt on current physics theory. If God or someone else designed the universe, it is not surprising that it is fine-tuned, any more than that the interconnected parts of a complex machine fit smoothly together to accomplish a particular function.

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[26] B. J. Carr says, "The first example of an argument which appeals to the strong anthropic principle was given by BRANDON CARTER..." B. J. Carr (1982) *Acta Cosmologica,* 11: 143-151, p. 148. Carter's paper is Brandon Carter (1974) "Large Number Coincidences and the Anthropic Principle in Cosmology," in pp. 291-298 of *Proceedings of the Symposium, Krakow, Poland, September 10-12, 1973.* Dordrecht, D. Reidel Publishing Co., 1974. Reprinted in *Gen Relativ Gravit* (2011) 43:3225–3233. The intellectual history of the idea is given in George F. R. Ellis "Editorial note to: Brandon Carter, Large Number Coincidences and the Anthropic Principle in Cosmology," *Gen Relativ Gravit,* 43: 3213–3223 (2011).

[27] Hugh Ross, *The Creator and the Cosmos*, 3rd edition, p. 153.

Our choice is thus not between intelligent design and random coincidence, but between intelligent design and current scientific theory. Without the feature of a designer, the finely-tuned fit to the data of several standard scientific theories is less probable than that the leaders in those subfields are lying or mistaken. Intelligent design also makes a falsifiable prediction: that current physics theory will continue to make correct predictions of reality, of which fine-tuning will be a part. The alternative, scientist fraud or error, implies that with time current scientific theory will prove to be in error. In that case, our prediction is that this will be discovered and generally acknowledged at some time in the next fifty years or so. Alternatively--- and this is the authors' preferred explanation--- we can accept the validity of intelligent design, which when combined with existing scientific theory and observation eliminates its dependence on improbable coincidences.

References

American Institute of Physics (2014) “Big Bang or Steady State?” http://www.aip.org/history/cosmology/ideas/bigbang.htm (2014).

Barrow, John D. and Frank J. Tipler (1986) *The Anthropic Cosmological Principle*. Oxford: Oxford University Press.

Behe, Michael (2003) “The Intelligent Design Hypothesis” in *God and Design: The Teleological Argument and Modern Science,* Neil A. Manson, ed., Abingdon: Routledge.

Bostrom, Nick (2003a) “The Simulation Argument: Why the Probability You Are Living in a Matrix Is Quite High,” *Times Higher Education Supplement* (May 16, 2003).

Bostrom, Nick (2003b) “Are You Living in a Computer Simulation,” *Philosophical Quarterly,* 53: 243.

Carr. B. J. (1982) “The Anthropic Principle,” *Acta Cosmologica,* 11: 143-151.

Carter, Brandon (1974) "Large Number Coincidences and the Anthropic Principle in Cosmology," in pp. 291-298 of *Proceedings of the Symposium, Krakow, Poland, September 10-12,1973.* Dordrecht: D. Reidel Publishing. Reprinted in *Gen. Relativ. Gravit.* 43: 3225–3233 (2011).

Collins, Robin (2003) “Evidence for Fine-Tuning” in *God and Design: The Teleological Argument and Modern Science*, Neil A. Manson, ed., Abingdon: Routledge.

Coles, Peter, ed. (1998) *The Routledge Critical Dictionary of the New Cosmology*, New York: Routledge.

Coles, Peter and George F. R. Ellis (1997) *Is the Universe Open or Closed? The Density of Matter in the Universe*, Cambridge: Cambridge University Press.

Davies, Paul (2006) *The Goldilocks Enigma: Why Is the Universe Just Right for Life?* London: Allen Lane.

Earman, John (2000) *Hume's Abject Failure,* Oxford: Oxford University Press.

Ellis, George F. R. (2011) "Editorial note to: Brandon Carter,Large Number Coincidences and the Anthropic Principle in Cosmology," *Gen Relativ Gravit,* 43: 3213–3223 (2011).

Fogelin, Robert J. (2003) *A Defense of Hume on Miracles.* Princeton: Princeton University Press.

Harrison, Peter (1995) "Newtonian Science, Miracles, and the Laws of Nature," *Journal of the History of Ideas,* 56: 531-553 (October 1995).

Holder, Rodney D. (2004) *God, the Multiverse, and Everything: Modern Cosmology and the Argument from Design*, Aldershot and Burlington, VT: Ashgate Publ.,.

Holder, Rodney D. (2013) *Big Bang, Big God: A Universe Designed for Life?* Oxford: Lion Books.

Hume, David (1748) *Enquiries Concerning Human Understanding and Concerning the Principles of Morals.*

Jones, Phil (2011)"Cherry-Picked Phrases Explained," University of East Anglia, http://www.uea.ac.uk/mac/comm/media/press/CRUstatements/rebuttalsandcorrections/phrasesexplained (November 23, 2011).

Koperski, Jeffrey (2005) "Should We Care about Fine Tuning?" *British Journal of Philosophy of Science,* 56: 303-319.

Leslie, John (1989) *Universes,* London: Routledge;

Lindley, David (2004) *Degrees Kelvin* (Joseph Henry Press, 2004).

Manson, Neil A. (2000) "There is No Adequate Definition of 'Fine-tuned' for Life," *Inquiry*, 43: 341–52.

McGrew, Timothy (2011) "Miracles," Stanford. First published Oct 11, 2010; substantive revision July 2, 2011.

McGrew, Timothy, Lydia McGrew and Eric Vestrup (2001) "Probabilities and the Fine-Tuning Argument: A Sceptical View," *Mind,* 110: 1027–1037.

National Academy of Sciences (1999) *Science and Creationism: A View from the National Academy of Sciences,* Second Edition.

Newton, Isaac (1687) *Principia.* 1687.

Paley, WIlliam (1794) *Evidences of Christianity*. http://www.gutenberg.org/ebooks/14780.

Parfit, Derek (1998) "Why Anything? Why This?", *London Review of Books*, pp. 24–27 (Jan 22, 1998).

Penrose, Roger (2005) *The Road to Reality*, New York: Vintage Books.

Perlmutter, S. et al. (The Supernova Cosmology Project) (1999). "Measurements of Omega and Lambda from 42 High Redshift Supernovae," *Astrophysical Journal,* 517: 565–586.

Plantinga, Alvin (2011) *Where the Conflict Really Lies: Science, Religion, and Naturalism* Oxford: Oxford University Press.

Rana, Fazale and Hugh Ross (2004) *Origins of Life,* Colorado Springs: Navpress.

Rasmusen, Eric (2014) "The Concealment Argument for Why No Proof for God's Existence Will Be Found," http://www.rasmusen.org/papers/conceal-rasmusen.pdf.

Rees, Martin (1999) *Just Six Numbers: The Deep Forces that Shape the Universe,* London: Weidenfield and Nicolson.

Riess, Adam G. et al. (Supernova Search Team) (1998) "Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant," *Astronomical Journal,* 116: 1009–1038.

Ross, Hugh (2008) *Why the Universe Is the Way It Is*, Grand Rapids: Baker Books.

Sklar, L. (1993) *Physics and Chance,* Cambridge: Cambridge University Press.

Smart, J. J. C. (1989) *Our Place in the Universe: A Metaphysical Discussion,* Oxford: Blackwell.

Sober, Elliott (2012) "Coincidences and How To Reason about Them," ch. 30, pp. 355-374 of *European Philosophy of Science Association Proceedings (Amsterdam 2009)*, Springer, 2012.

Swinburne, Richard (1970) *The Concept of Miracles*, London: Macmillan.

Taylor, James (2011) *"Climategate 2.0: New E-Mails Rock The Global Warming Debate," Forbes* (11/23/2011).

Thomson, William (Lord Kelvin) (1862) "On the Age of the Sun's Heat," *Macmillan's Magazine*, 5: 288-293 (March 5, 1862), http://zapatopi.net/kelvin/papers/on_the_age_of_the_suns_heat.html#fn2b.

Peter van Inwagen (1993) *Metaphysics,* Boulder, Colorado: Westview Press.

White, Roger (2000) "Fine Tuning and Multiple Universes," *Nous*, 34: 260-276.

Wigner, Eugene (1960) "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," in *Communications in Pure and Applied Mathematics*, 13: 1-14 (February 1960).

Wright, David McCord, John Maurice Clark, Gottfried Haberler, Frank H. Knight, Kenneth E. Boulding, Edward H. Chamberlin, Milton Friedman, and Paul A. Samuelson (1956) *The Impact of the Union: Eight Economic Theorists Evaluate the Labor Union Movement* New York: Kelley & Millman.