Fine-tuning is not surprising

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A number of recent works by physicists and others have noted what appears to be a very surprising coincidence. If the constants of physics had been slightly different, life as we know it would not have existed. This has astonished the writers of those works, and several explanations have been suggested. A popular explanation for fine-tuning among non-physicists has been that a Divine Intelligence has seen to it that the constants were set to just the right values for life as we know it to emerge.[1] The most popular explanation for fine-tuning among physicists seems to be that our universe is one among an enormous number, where the values of the constants vary across these universes (e.g. Singh 2005: 487–88). This 'many-universes' explanation is supposed to make fine-tuning unsurprising via an argument along something like the following lines. Since universes of practically all relevant types, both tuned and untuned, exist, it is unsurprising that some universe of our finely-tuned type exists. Further, since only such universes contain living things, it is unsurprising that we living things observe that our own universe is fine-tuned for life.

What I am calling the 'standard fine-tuning argument' is an argument that fine-tuning, i.e. the values of the constants in our actual physical laws on the one hand, and the values compatible with life as we know it on the other, and the precise 'match' between them, jointly yield a surprising coincidence. I will argue against that view, and for the view that fine-tuning is an expected consequence of unsurprising features of the actual physical world and of life as we know it. I conclude that the fact that there is some fine-tuning for the existence of life as we know it is fairly unsurprising, given what we know.

One relevant feature of our world is that it consists of some smallish number (less than 100, say) of basic components, and that the behaviour of these components is governed by (alternatively, accurately modelled by) some smallish number of coupled partial differential equations. Let's label this feature of our universe *moderate complexity*. There is a sense in which moderate complexity is highly improbable, at least in terms of some 'logical' notion of probability. Out of all the logically possible ways that the world might have turned out, it ends up having less than 100 or so basic types of entities, and these entities and their interactions are ac-

[1] Some authors think that the fine-tuning phenomenon '[t]oday … is widely regarded as offering by far the most persuasive current argument for the existence of God' (Collins 2000).

ANALYSIS 66.4, October 2006, pp. 000–000. © Cory Juhl

curately represented by fewer than 100 or so coupled differential equations. How surprising is this fact? Does it 'cry out for explanation'? Another relevant feature of our world is the 'sensitivity' of many of its features to precise values of the constants in the fundamental laws. Given a reasonable number of laws that posit reasonably complex interactions between fields, is it surprising that many interesting actual features of the universe require that the constants have values close to their actual values? In the absence of careful mathematical analysis yielding results to the contrary, some 'sensitivity' seems unsurprising, given moderate complexity. So let us focus on moderate complexity and how surprising it is.

Barrow and Tipler (1986), who have done the most to popularize the fine-tuning 'coincidences', were not struck by the fact that the physics of our world has several basic laws and constants. What they were struck by was the fact that if these constants had been significantly different, life as we know it would seem to be impossible (to arise spontaneously, in accordance with physical laws). It is the apparent 'coincidence' between the values of the constants and the values seemingly required for the existence of life as we know it that seemed surprising. The precise settings of the constants are improbable no matter how they are set, one might think. What is really striking, according to fine-tuning enthusiasts, is the coincidence, the precise 'match', between those settings and the settings compatible with life as we know it.

In order to motivate the thought that a genuine or interesting coincidence is present, one would need to show that the fact that actual settings of the constants would be within some small neighborhood of their actual values is an event of low probability. A number of objections to the fine-tuning argument have been made along this front. Some of the more sophisticated ones note technical difficulties associated with probabilities of events within infinite spaces. The one that I will rely on here is less sophisticated, but nevertheless important. We simply have absolutely no idea what the probabilities are for the settings of various constants. It is true that if we select a particular space of possibilities, and an intuitively uniform measure on that space, the probability that some constant lies within some region of values turns out to be low on that measure. But it is important to remember that the space is made up out of thin air. When considering the actual physical probability of such an event, we have absolutely no idea what it is, and unclear prospects for discovering what the true physical probability is. If we prefer to introduce a 'logical' probability measure, we immediately run into the sorts of technical difficulties that have continued to challenge 'logical' theories of probability. There are simply too many different 'logical' measures that could be used, all with equal naturalness or arbitrariness.

The unsurprising feature of life as we know it is that it is *causally ramified*. Being causally ramified in our stipulated sense is causally depending, for its existence, on a large and diverse collection of logically independent facts. For example, life as we know it involves carbon, so carbon must exist if life as we know it is to be possible. It also employs oxygen, so oxygen must exist for similar reasons. If life is to arise spontaneously on a chunk of matter, there must be a chunk of matter containing both elements in sufficient amounts. That chunk must not be too hot or too cold. It must survive long enough, and contain enough other elements, for some complex of chemical reactions to take place. Nearby stars should neither absorb these chunks, nor go into supernovae too quickly. And so on and so forth. Is life as we know it causally ramified? On some reflection, it seems obvious that it is. Is this fact surprising? It is difficult to see why. Furthermore, the proposition that life as we know it is causally ramified is not what is taken to be surprising, or particularly a priori improbable, in standard fine-tuning arguments. For that reason it will not require lengthy defence in the context of the argument of this paper. Nevertheless, it may be worth motivating the claim further, since causal ramification is an essential part of the explanation of fine-tuning.

Imagine that one were to read a paper that merely stated that life as we know it presupposes or requires the existence of a number of essential elements, essential compounds, that there are constraints on temperature, the length of time during which these other features are all present, and so on. If it did not cite the particular facts causally presupposed, but only the fact that some large number of such facts is required, we would not find this general feature, causal ramification, particularly surprising. Many other objects are causally ramified. Mt. Everest is one such object. To produce an object with that particular configuration of elements and compounds, even leaving aside those of biological origin, requires narrow ranges for parameters within fundamental laws in qualitatively the same way as does life as we know it. Practically any non-microscopic chunk of matter in the universe is causally ramified in similar ways. Yet one does not observe fine-tuning arguments for an intelligent designer or for many universes from the existence of a pebble in one's back yard. Or a pebble-sized chunk of rock in some other region of the galaxy. Thus it is not the mere observation of causal ramification of life as we know it that is surprising or improbable, that provides the grist for the fine-tuners' mill.

For many moderately complex systems S, most causally ramified phenomena within S will exhibit sensitivity to fundamental parameters that describe the structure of S. The claim can be made more precise in an indefinite number of ways, but the basic idea is rather simple and seems obvious once pointed out. Suppose, for a simple model of this phenomenon, that some data set corresponding to some physical system S is 'fitted' with some complicated polynomial curve selected from a class of candidate data-fitting curves. A causally ramified phenomenon within system S will likely depend on a fairly wide range of features of the curve, such as the number of maxima and minima, curvatures at various locations, and others. It is likely that many of the constant factors of the polynomial will be highly constrained by the broad subsets of the data that correspond to causally ramified phenomena within such a system. If we have several polynomials that share some variables, or coupled partial differential equations, even greater sensitivity should be fairly typical, if not virtually certain. But such sensitivity to the precise settings of the constants is just fine-tuning.

Nevertheless, we do not even need to make a general claim about arbitrary systems of moderate complexity in order to press the point about fine-tuning of our constants for life as we know it. All that we need for present purposes is that our own universe is moderately complex in a particular way, and that many phenomena that are causally ramified within our world depend sensitively on the fact that certain constants within the basic laws are within narrow ranges. None of this is particularly surprising, given the sort of moderately complex universe that we actually live in.

Now let us return to the fine-tuning argument. Most popular and semipopular fine-tuning arguments are of the form: Life as we know it depends on an extremely narrow range of values for the basic constants. Furthermore, the basic constants happen to be in precisely those ranges. This is very surprising coincidence, given a natural 'space' of possible values for those constants. Theists conclude, after further argumentation, that an Intelligent Designer 'tuned' the constants to precisely those values, and this fact best explains why a universe with such surprising/logically improbable fine-tuning exists. Atheists often conclude that many universes exist, and this fact best explains why one with such surprising/logically improbable fine-tuning for life exists.

The considerations adduced above suggest that both arguments from fine-tuning to extravagant consequences are at best premature. It is not yet clear, given the actual moderate complexity exhibited by the basic laws, that we have been shown a surprising phenomenon requiring an exotic explanation. Given that the actual universe has a couple dozen or so basic laws and types of basic particle, interacting in complex ways, we should expect that practically any causally ramified phenomenon, from a pebble floating somewhere in space, to Mt. Everest, to a galaxy, is such that its existence depends sensitively on the fundamental constants. The phenomenon is commonplace. Given a mathematical representation of a complicated data set, any complicated subset of the data will constrain the components of the overall representation. The more complicated or ‘ramified’ the subset, the greater the constraints on the overall representation.

Note that the conclusion is that fine-tuning arguments are premature, and rationally unconvincing in the absence of further insight. Merely pointing out generic fine-tuning, sensitive dependence of the existence of life as we know it to values of parameters in our actual laws, is not enough to show something surprising. Such sensitivity is precisely what should be expected, given our variety of moderate complexity and the degree of causal ramification of life as we know it.

This observation leaves open the possibility that someone might show, via more careful analysis, that on any reasonable measure, the ‘degree of fine-tuning’ is surprising even given the sort of moderate complexity actually present in our universe, and given the degree of causal ramification of life or some other phenomenon. It could turn out that, in some mathematically interesting sense, the degree of sensitivity of global features to variation in constant settings is very surprising. Such analyses are absent from (and not appealed to by) the best known literature on fine-tuning phenomena. The authors that I have read simply take it for granted that fine-tuning is a very surprising coincidence. What I have argued here is that fine-tuning per se should have been expected ever since we came to know that life is causally ramified and that the physics of our world is moderately complex. Before rushing to exotic explanations involving super-Beings or super-universes, we should make sure that we have encountered a phenomenon genuinely requiring such extravagant posits.

Although this paper is not intended to address the entire panoply of objections and possible replies pertaining to fine-tuning arguments, it is perhaps worth noting a difference between the point raised here and another objection that has been raised to the standard fine-tuning argument. The objection is that the fact that we observe the universe to have constant values that ‘match’ those compatible with life is not surprising, in spite of the fact that the coincidence has an extremely low probability. The reason, according to this objection, is that if the constants did not have values close to their actual values, there would be no observers around to note this fact. An ‘observer selection effect’ ensures that any observed values will be close to the actual values. Therefore, according to this objection, we should not be surprised that the values observed are within their actually observed ranges. A common response to this objection is that the fact that we would not be around to observe other, ‘untuned’ values does not diminish the surprise that one should rationally feel about the values being ‘just right’ for life as we know it to be possible. An oft-cited analogy is the case of a kidnapping victim who is shown an elaborate device that will kill him unless an ace of hearts is selected via random selection from each of ten decks of cards that have been thoroughly shuffled. If the victim were to survive, he would be rationally justified in being extremely surprised, and would be rationally justified in seeking an explanation for his amazing good fortune. An objector analogous to the one just mentioned would argue, 'No, you shouldn't be surprised at all. You wouldn't be here thinking about it if the incredible coincidence had not occurred'. On this point I side with the fine-tuner, against the objector. Pointing out selection effects in such a setting seems beside the point. An amazing coincidence has indeed occurred (although whether divine intervention or many universes would be required or provide good explanations is a further question).

The point defended in this paper can be contrasted with the objection just outlined. Our target has been the presupposition that 'fine-tuning' per se is surprising. Furthermore, we should deny that the analogy to the kidnap victim is apt, in two crucial respects. Let the output of the card shuffling/selection device SSD be the analogue of the constants having particular values. Let the fact that life as we know it requires the constants to have values within restricted ranges be the analogue of the kidnap victim's continued existence requiring the output of the SSD to be a sequence of ten aces. One disanalogy between our actual fine-tuning case and the kidnapping case is that within the imagined kidnapping case we have implicit knowledge about the causal structure of the SSD that rationally leads us to think that any particular sequence of cards is indeed highly improbable. We have no such knowledge concerning the laws and constants of physics. We simply do not know how improbable it is that they would be exactly as they are. A more apt analogy would be one in which the kidnapper's device outputs some sequence of cards, and that sequence is 'logically improbable', but we have no idea what the internal structure of the device is. For all we know the device always outputs precisely those values. If we have no idea whether the cards have been shuffled, or even whether there are any other cards to be possibly selected, then it is unclear whether the sequence generated is improbable. A second disanalogy is that in the kidnapping example as presented, we are given an 'independently interesting' sequence, ALL ACES OF HEARTS, as a 'target' sequence. The 'specialness' of that sequence does a lot of the intuitive work in the example, arguably. But in typical discussions (in particular, those of physicists) it is not claimed[2] that 'life as we know it'

[2] Some, such as Dembski, have tried to assimilate the fine-tuning arguments as special cases of his own arguments that appeal to 'specified complexity'. I distinguish Dembski's 'impure' approach from standard or 'pure' versions of the fine-tuning argument that focus on the supposed surprising coincidence between constant values and the values required for life, without appeal to any further 'special' features of life as we know it. Addressing Dembskian 'specified complexity' is beyond the

could have been described as an interesting pattern independently of simply empirically examining life as it actually exists, with all its baroque and quirky kludging.

We should anticipate that we will, on closer examination and analysis, continue to find further ways in which subsystems' structures constrain the parameters that characterize our universe. If this is right, then an open-ended continuing sequence of discoveries as to how this or that requirement of life as we know it further constrains the fundamental constants is not by itself further evidence for an Intelligent Designer. We should confidently expect a cascade of such developments, both because of the nature of data fitting (broader subsets of data further constrain the 'fitting' parameters) and because of the existence of fine-tuning advocates searching for further constraint-yielding phenomena. Such discoveries are predictable with practical certainty, independently of whether there is a Designer or a Multiverse.[3]

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scope of this paper. A number of criticisms have been made elsewhere. See, e.g., Allen Orr's review of Dembski's *No Free Lunch*.

[3] Thanks to Josh Dever, Jack Justus, Rob Koons, Al Martinich, Bryan Register, Sahotra Sarkar, David Sosa and Todd Stewart for helpful discussions of these matters.