

# **The Fine-Tuning of the Universe: A Philosophical Analysis**

by

**Graham Wood**

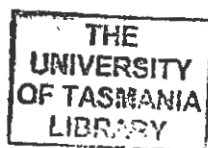
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## Abstract

This thesis is a philosophical examination of the *fine-tuning* of the Universe. It is in two parts, the first part examines the apparent improbability of the fine-tuning and the second examines responses to that apparent improbability.

I begin part one by examining the physical theories that have generated the fine-tuning debate. I argue the debate presupposes a realist interpretation of numbers, scientific theory and laws of nature. Without these presuppositions the concepts of *slightly different* laws and initial conditions of the Universe should be interpreted as mathematical artifacts. I then go on to analyse the *possibility space* of universes. Physical possibility is excluded and logical possibility is unsatisfactory, so I introduce *ontic* possibility space to examine the possibility of other universes. I consider the evidence that slightly different universes are not life-allowing, and I suggest two theories that could explain this evidence. Ontic possibility space may be *chaotic* such that 'neighbouring' universes are substantially different in structure from our own. Alternatively ontic possibility space may be *quantised* such that slightly different universes are not ontically possible. I then consider the claim that this fine-tuned universe is improbable. I analyse the role of probability in the debate and use partitions of the *probability space* to examine the fine-tuning. I conclude that the fine-tuning can be considered improbable only if it is taken to be objectively significant. Without this the fine-tuning is *isoprobable*, meaning that it is as probable as any other outcome.

In part two I consider the responses to the improbability. Two responses are attempts to *explain away* the improbability, either by postulating many universes or God. I also consider the possibility that this universe is the isolated result of an indeterministic ontic process. I examine the role of probability in explanation, focusing on the impact of indeterminism on this process. Often explanations are favoured that raise the probability of events. However I show that this can lead to error when considering isolated events in indeterministic systems. To avoid this error I apply the *conformity maxim* – explanations should generate epistemic probabilities that match ontic probabilities. I then go on to consider what triggers the need for explanation including an analysis of *surprising* and *specified* events. In considering the explanations of the fine-tuning, I analyse the *multiple universe* and *design* explanations. I conclude that the best response to the fine-tuning is to consider the universe as an isolated outcome of an indeterministic ontic process, possibly grounded in chaos or quantum theory.

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# 1 The Thesis and the Fine -Tuning Debate

## 1.1 Introduction

The laws of science as we know them at present, contain many fundamental numbers, like the size of the electric charge of the electron and the ratio of the masses of the proton and the electron. ... The remarkable fact is that the values of these numbers seem to have been very finely adjusted to make possible the development of life. For example if the electric charge of the electron had been only slightly different, stars either would have been unable to burn hydrogen and helium, or else they would not have exploded. Of course, there might be other forms of intelligent life, not dreamed of even by writers of science fiction, that did not require the light of a star like the sun or the heavier chemical elements that are made in stars and are flung back into space when the star explodes (Hawking 1989) 131-132.

*If the laws and/or initial conditions of the universe had been slightly different then carbon-based life would not be possible.* This is the basis of the fine-tuning debate. The apparent fine-tuning of the universe has engaged the minds of both physicists and philosophers, perhaps because it touches on important questions relating to the nature of existence and our place in it. Presumably the values in the laws and initial conditions could have been otherwise, and further could have been otherwise in many different ways, hence, for many, the values are in some sense improbable.

In this thesis, I will use the phrase 'the fine-tuning' to refer to the relevant features of the laws, and initial conditions of this universe that allow for life. The fine-tuning has prompted some to suggest the existence of many other universes, with different laws and initial conditions (Lcslic 1989). It has appeared to others as evidence for the existence of God (Swinburne 1990). Still others claim that the fine-tuning can simply be understood as the result of chance (Scriven 1966). All these responses can be considered as reactions to the perceived improbability of the fine-tuning.

In this thesis I will undertake a philosophical analysis of the fine-tuning of the universe. There has been extensive discussion about the improbability (or otherwise) of the fine-tuning and about the responses to that alleged improbability. Often these responses are explanations that in some sense *remove* that improbability. However, while much has been said, much remains unsaid. There are important implicit presuppositions that

remain unanalysed in the fine-tuning debate. This thesis will attempt to uncover and analyse them. They relate to: the contingency of laws and initial conditions; the appropriate modality of the discourse; the nature of the possibility space of universes; the relation between probability and explanation (specifically with respect to indeterministic systems); and assumptions in the current explanations of the fine-tuning.

### *1.1.1 Thesis issues*

The core issue of this thesis directly concerns the fine-tuning of the universe. However, an additional strand uses the fine-tuning controversy to examine several broader issues. One issue concerns the distinction between our ideas about reality and reality itself. I take it as uncontentious that we want our ideas about reality to match reality. We want our ideas about reality to be 'true'. We want our concepts (the epistemic) to match reality (the ontic).<sup>1</sup> To use an analogy, the epistemic can be thought of as a *map* and the ontic can be thought of as the *territory*. We want the map to correspond to the territory. I will use this distinction to consider issues about possibility and probability.

In this thesis I assume that possibility and probability exist in the world independently of our knowledge or beliefs about them.<sup>2</sup> Ideally we want epistemic possibility to match ontic possibility. We do not want to *believe* something is possible if it is 'really' impossible. Further we want epistemic probability to match ontic probability. Here I am using the term epistemic probability differently from how it has been used in the probability literature. Conventionally, epistemic probability is taken to be our 'degree of belief' that a certain state of affairs is true. Thus, for instance, we can believe with a probability of 20% that a certain atom decayed, or we can believe with a probability of

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<sup>1</sup> The choice of the terms epistemic and ontic is not completely unproblematic. However they are workable. The 'epistemic' is the conceptual. The term epistemic strictly refers to knowledge, but in this context it also refers to belief. The ontic is reality. Previously the ontic has been distinguished from the ontological (Heidegger 1962) 31. This distinction parallels the distinction made by Edmund Husserl in his *Logical Investigations* (Husserl 1970) between formal ontology and material or regional ontology (Smith 2000) 373. Regional ontology is appropriate for the subject of this thesis, thus I use the term ontic.

<sup>2</sup> This assumption is based on the existence of physical indeterminism. I take this to mean that there exist possibilities and probabilities in the world, independent of our minds.

30% that the atom decayed. This refers to our *confidence* in our belief. However, I am using epistemic probability to refer to our belief *about* ontic probabilities. Thus we can believe that the 'real' probability of the decay of the atom was 20%. We would hope that our epistemic probability about this event matches the ontic probability.

If something is ontically probable (or improbable) we want our idea of that thing to have a matching epistemic probability (or improbability). Importantly, the relation between the epistemic and the ontic allows for epistemic error. But I take it for granted that we want to avoid such error. We do not want to think something is epistemically probable when, in fact, it was ontically improbable or alternatively, we do not want to think something was epistemically improbable when it was ontically probable. So we should attempt to ensure that our ideas about possibility and probability correspond to the possibilities and probabilities in the world.

Another important issue concerns epistemic conservatism. When considering other possible universes it is easy to play loose with logical possibility and logical probability (or more specifically logical improbability, when we are dealing with an infinity of other logically possible universes)<sup>3</sup>. And rather than employ the permissive assumption that all that is logically possible is ontically possible, I will be more conservative. I will not assume this. I will build out from physical possibility to postulate the nature of ontic possibility. I will use what we have good reason to believe is possible in the physical world, by that I mean what is possible given the laws and initial conditions of the physical world, to underpin what might be ontically possible. When considering the nature of ontic possibility I will use ideas related to chaos and quantum theory, theories that are grounded in the physical reality of this universe, to postulate the nature of the ontic possibility space of universes.

The last issue I will consider is indeterminism. Contemporary science has embraced indeterminism, where the current state of a system, together with the laws of that system,

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<sup>3</sup> Here I am using the term logical probability more broadly than others in the probability literature, for example (Carnap 1950). I use the term logical probability to refer to the probabilities that attach to possibilities in the logical possibility space. These probabilities form logical probability space.

do not uniquely determine the future states of that system (Dowe 1997) 4. However, if we are to accept this notion, then we must revise our explanatory expectations with respect to indeterministic events. Importantly, in reference to the origin of the universe, the fine-tuning may be the outcome of an indeterministic process. So we must understand the impact of indeterminism (interpreted probabilistically) on our explanatory strategies when we attempt to understand the fine-tuning. I will argue that the possibility of an indeterministic explanation of the fine-tuning has profound implications for how we assess explanations in the fine-tuning debate. My analysis has uncovered a serious problem relating to how probability is used to decide between explanations when one or more of those explanations are indeterministic. Generally, we favour explanations that (in a sense to be examined in more detail later) *raise* the probability of that being explained. However, if we accept the reality of indeterminism, then this method of choosing explanations may yield erroneous explanations. In an indeterministic world we do not necessarily want explanations that raise the probability of that which they explain, but rather we want explanations that generate epistemic probabilities that accurately map ontic probabilities. In an attempt to better choose between indeterministic explanations, I present the *conformity maxim*.

*Explanans should generate epistemic probability distributions that conform to the ontic probability distributions of the explananda*

### *1.1.2 Thesis boundaries*

Before presenting an overview of the structure of the thesis I will outline the *boundaries* of this thesis. The thesis covers much, but it cannot cover everything. Essentially the thesis is a philosophical analysis of the fine-tuning of the universe such that it allows for life. But there are some interesting philosophical issues closely related to the fine-tuning that this thesis simply cannot deal with in detail. These include: the explanation of the *actual* existence of life, (as distinct from any explanation of the fine-tuning for the *possibility* of life), the question of whether life is objectively or subjectively significant, and the nature of God. These issues will be referred to in the following discussion of the structure of the thesis but they should be taken to define the boundary of this work, rather than its body.

Finally a word needs to be said about the *anthropic principle*. Brandon Carter introduced this principle to highlight a refinement of the Copernican principle (Carter 1974). While we should not assume that we occupy a central position in the universe (the Copernican principle), we can assume, *indeed we must assume*, that we occupy a position in the universe that allows for our existence. Self-evidently, it is not possible that we exist in a universe (or in any spatiotemporal part of a universe) that does not allow for our existence. There has been much discussion in the literature concerning this principle, and variations of it (Earman 1987). I will bypass this discussion. However, I endorse what is called the ‘observation selection effect’ (Bostrom 2002). This is the self-evident fact that observers can only observe a universe (or some spatiotemporal part of a universe) that allows for that observation. Although in the case of the fine-tuning of the universe for *life*, rather than for *observers*, it may be more appropriate to think of an ‘existential selection effect’. Life (or anything else) cannot exist in a universe (or a spatiotemporal part of a universe) that does not allow for its existence.

## **1.2 Possibility and Probability**

This thesis has two parts. The first part (to Chapter Seven) examines the claim that the fine-tuning is improbable and the second part (from Chapter Eight) examines the appropriate responses to that claim. This division largely reflects the point that many presuppositions implicit in the debate have not been explicitly examined in the current literature. Due to this, much of the first part concerns issues that are not normally associated with the fine-tuning debate, issues such as realism versus antirealism in science, the appropriate modality of the discourse and the appropriate interpretation of probability. The fact that discussion of these issues is largely absent in the current debate is because, to a large extent, certain positions are being uncritically assumed. The first part examines these assumptions to determine their significance. The second part is more recognisably located in the current debate and largely concerns the explanatory responses to the fine-tuning. However, there is another important aspect of the second part that is not traditionally associated with the fine-tuning debate and this concerns the impact of indeterminism. Current physics suggests that the laws and initial conditions of the universe may have been set indeterministically, through a process of ‘symmetry

breaking' (Rees 2003). So we must analyse our ability to explain indeterministic systems (understood probabilistically) before we can respond appropriately to the apparent improbability of the fine-tuning.

At each point in the thesis there will be positions considered (such as antirealism with respect to laws of nature) which advocates of these positions would claim undermine the fine-tuning debate. The structure of the analysis will furnish many opportunities for such people to 'opt out' of the debate. However this will not be sufficient to end the analysis. The analysis will start with the assumptions necessary to launch the fine-tuning debate and will end with consideration of the explanations of the improbability of the fine-tuning, even if, as a result of this analysis, it is determined that the fine-tuning is not improbable. Now let me consider the detailed structure and content of the thesis, which is effectively the structure and content of the fine-tuning debate.

### *1.2.1 The basic fine-tuning conditional*

*If the laws and/or initial conditions of the Universe had been slightly different then carbon-based life would not be possible.*

There is much presumed in this conditional. Much of the first part of the thesis will examine the presuppositions of the *antecedent* of this conditional. But first let me consider the *consequent*, "carbon-based life would not be possible". The issues related to the consequent are not central to this thesis but I will discuss them briefly.

First, what is life? We could simply equate it to 'carbon-based life'. But this is unnecessarily restrictive. There may be other forms of life that are not carbon-based, but nonetheless are recognisable as life (Hawking 1989) 132. Life as we know it happens to be carbon-based. But this does not necessarily mean that life *must* be based on carbon. Although working biologists do not necessarily need a definition of life to know what they are talking about (Sterelny and Griffiths 1999) 357, a definition of life is important for the fine-tuning debate. The characterisation of the essential nature of life is central to 'universal biology' (Cleland and Chyba forthcoming). The universal biology project is not well advanced but for our purposes I will assume that it is theoretically possible to specify the essential nature of life, such that we can determine whether a universe is *life-*

*allowing*, or *life-precluding*. And unless otherwise specified throughout the rest of this thesis 'life' will refer to 'universal life'.

Second, setting aside the question of non-carbon-based life, there are still many forms of living organism. The *sentriocentric* among us may not take a universe containing only prokaryotic life as compelling evidence for the existence of God. If all the life in the universe were unconscious single-celled organisms would this undermine the need to explain the fine-tuning? I contend that it is the existence of 'intelligence' or 'consciousness' that drives much of the fine-tuning debate (Davies 2003) 153.

Third, while the fine-tuning is *necessary* for the existence of carbon-based intelligence or 'consciousness' it is not *sufficient*. The fine-tuning does not *ensure* the existence of consciousness. The fine-tuning does not even ensure the existence of carbon-based life. I will take the existence of consciousness to be the result of many (apparently) contingent events in the history of this planet that are (apparently) supplementary to the fine-tuning of the universe. To be clear, some writers, for example Paul Davies, think that the emergence of consciousness is 'assured' by the fine-tuning (Davies 2003) 153. However; others disagree; Stephen J. Gould describes consciousness as a 'quirky evolutionary accident' (Gould 1987) 431.

I will not attempt to settle whether the fine-tuning ensures the existence of intelligence, or consciousness. I will assume that the fine-tuning *does not ensure* the existence of intelligence or consciousness. Further I will assume that the fine-tuning does not ensure the existence of carbon-based life. All that the fine-tuning does is allow for the *possibility* of carbon-based (possibly intelligent) life. In short, this thesis is largely about the fine-tuning for the *possibility* of life, not the fine-tuning for the actual *existence* of life, although the actual existence of *intelligent* (carbon-based) life will feature when I consider the design argument. Now let me turn to the antecedent of the conditional: *If the laws and initial conditions of the Universe had been slightly different...*

### *1.2.2 Possible universes?*

The first presupposition in the debate is that the laws and initial conditions *could have been different*. This may be a mistake. It may be that the apparently fine-tuned features of the universe are fixed by necessity. There may be only one possible set of values. This relates to what has been called a ‘theory of everything’ or a ‘complete unified theory’. Davies describes physicists investigating whether only one universe is logically self-consistent (Davies 1993) 165. Stephen Hawking considers the possibility of a theory that predicts all the fine-tuned features of this universe (Hawking 1989) 131. Now the necessity being considered is not necessity of *existence*. Such a theory does not answer the question, “Why does the universe go to all the bother of existing?” (Hawking 1989) 184. In other words, a theory of everything does not answer the question of why is there something rather than nothing? (van Inwagen 2002) 132. A theory of everything, if it exists, will answer the question: “If a universe exists why does it have to be this way?” So here we are not considering the necessity of the *existence* of the universe but rather the necessity of the *form* of the universe. Some are hopeful for a theory of everything, others are not. Davies believes that the universe could have been otherwise (Davies 1993) 169 and for the purposes of this thesis let us make the same assumption.

So the fine-tuning debate embraces some form of contingency. This presupposition relates to modality. But what kind of modality? It cannot be mere physical modality, because that is normally understood to relate to what is necessary or contingent *given* the laws and/or initial conditions of the universe, and these are the very things we are supposing to be different. Another option is logical modality. If we take logically possibility to be all possibilities that are not self-contradictory, then there appear to be many other ways that the universe could have been tuned. If the fine-tuned parameters range over all logical possibilities, then it might seem surprising that they hold the values that they do. But I question the application of logical possibility here. Why is logical possibility the appropriate modality? To say a state of affairs is logically possible is only to say that it is not contradictory. But the mere fact that some state of affairs is not self-contradictory does little to provide understanding. I contend that the application of logical possibility *simpliciter* is a mistake. Logical possibility can stimulate boundless

*ideas*, but when it concerns understanding the *actual world*, the task is to *exclude* some of the logical possibilities. Thus I propose a different approach. While we cannot use physical possibility *directly* we can use it to develop our understanding of the fine-tuning. I propose to *extrapolate* from what we know about physical possibility, to explore the nature of a ‘larger’ possibility space within which physical possibility is but one possibility. This underpins my advocacy of ontic possibility, as distinct from logical possibility. The ontic possibility of universes grounds what universes are ‘really’ possible.<sup>4</sup> One task of my thesis is to lend sense to the notion of ontic possibility, which our (ontically actual) fine-tuned universe exemplifies. The exploration of ontic possibility may even be related to a theory of everything.

### *1.2.3 Defining possible universes*

Imagine an  $n$ -dimensional space.<sup>5</sup> This space is not the space-time in which we exist. Each dimension corresponds to one aspect of the laws and initial conditions of the universe. For example, the gravitational constant corresponds to one dimension in this space. The strength of the gravitational constant in this universe is represented by the value  $6.664 \times 10^{-11}$  on this dimension. Possible universes with a gravitational constant of the same strength are represented by the same value on this dimension. Possible universes with a gravitational constant of different strength are represented by different values along this dimension. The other numbers associated with the laws and initial conditions of this universe can be represented in a similar way. Thus, for the purposes of this analysis, this universe is specified by the co-ordinates in the  $n$ -dimensional space that correspond to the values of all the variables in the laws and initial conditions of this universe. All the other possible combinations of co-ordinates in this  $n$ -dimensional space specify other possible universes.<sup>6</sup> This is what I term the possibility space of universes.

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<sup>4</sup> The term metaphysical possibility is used in the literature, but it is not always clearly distinguished from logical possibility (Pruss 2002) 317.

<sup>5</sup> This is based on the ‘probability phase space’ idea used by Phil Dowe in the manuscript “The Inverse Gambler’s Fallacy Revisited: Multiple Universe Explanations of Fine Tuning” (Dowe)

<sup>6</sup> The number of dimensions is not set by the number of features of this universe. But on all dimensions that correspond to features that do not exist in this universe, it is located at the zero value.

And by recording a probability against each possible universe in this space we can conceptualise the probability space of possible universes.

There are some problems with possibility and probability spaces. The most obvious is how to construct this space. In the first instance, we construct this space based on the features of this universe. So the dimensions of the space are defined by features of this universe. But the problem then is that there is no potential for representing the features (of other possible universes) that are not instantiated in this universe. To attempt to avoid this problem we could simply assign dimensions to 'unknown features', but this would be unacceptably imprecise. And on a more practical level, there is the problem of our limited ability to conceive of and/or visualise a space with enough dimensions to define the features of all possible universes. To mitigate the conceptual challenges that this space presents, we will use simplified versions in this analysis. This approach does not allow us to uniquely specify every possible universe. If a point in the possibility space involves indeterministic laws, then this point will represent more than one possible universe. But it does allow us to specify the features of the universe that are relevant to the fine-tuning debate.

Having defined the possibility space of universes we can consider modality. Some modalities may exclude some portions of this space. Physical possibility is only one point in the possibility space, namely the point that represents the laws and initial conditions of this universe. This is simply because physical possibility is that which is possible *given* the laws and initial conditions of the universe. Other modalities may allow for more points in this n-dimensional space. Logical possibility space is all the points in this space that are not self-contradictory. We are interested in ontic possibility space. We want to know what other universes are 'really' possible.

#### *1.2.4 Different numbers, theories and laws?*

With the n-dimensional space in mind, let me consider the antecedent of the fine-tuning conditional, the possibility that the laws and initial conditions could have been different. Assume for argument's sake that the laws 'really' could have been different. Consider the electric charge of the electron, which is  $1.602192 \times 10^{-19}$  coulomb. Assume that it is a

law of nature that all electrons have this charge. So how could this have been different? It seems logically possible that the electron could have had a different charge. Imagine changing the numbers in the charge to  $1.302192 \times 10^{-19}$  or  $1.602192 \times 10^{-17}$ . This does not seem to lead to logical contradiction (although it may) so this seems logically possible. But what does changing the numbers imply about what is *really* possible? To understand this, consider the status of *numbers* in scientific theories and laws of nature. This in turn leads to the need to understand the *nature* of scientific theories and laws of nature. Specifically, are they to be given a realist or antirealist interpretation? There are references to the interpretation of laws and theories in the fine-tuning debate. Davies believes that laws of physics “really exist in the world” (Davies 2003) 149. Hawking is more cautious; with respect to theories he believes that they exist “only in our minds” and that they don’t “have any other reality (whatever that might mean).” (Hawking 1989) 10. However, these assumptions have remained largely unexamined in the fine-tuning debate. This thesis will analyse the role of numbers in science (Brown 2000), the interpretation of scientific theories (Suppe 2000; Giere 2000) and the interpretation of laws of nature (Harré 2000), in order to assess the implicit assumptions in the debate. I will argue that one must assume a realist interpretation of numbers, scientific theories, and laws of nature for the fine-tuning debate to be well founded. Without these presumptions the ‘different’ laws and initial conditions should rather be considered as mathematical *artifacts*.

### *1.2.5 The nature of ontic possibility space*

The current fine-tuning debate largely discusses probability without first discussing possibility. Much is said about the improbability of the fine-tuning without due analysis of the possibility space of universes. While an analysis of probability is central to the fine-tuning debate it tends to obscure consideration of the possibility of different fine-tuned values. Possibility is logically prior to probability, since we cannot clearly understand what is probable or improbable before first understanding what is possible or

impossible. An event cannot have a *probability* (other than 0) unless it is *possible*.<sup>7</sup> This thesis will attempt to redress this omission. There are references to modality in the physics literature ranging from the minimal position that the universe could have been otherwise (Davies 1993) 169, to the suggestion that there are infinitely many actually existing universes (Smith 1986). Further, the possibility space that is considered in the philosophical literature appears largely to be logical space, (Leslie 1989) 138, (Swinburne 2004) 172.<sup>8</sup> But the analysis of the fine-tuning would benefit from a more extensive consideration of possibility. We need to ask how the universe might have been different? Are there many different possible universes or only a few? Is the possibility space of universes, (to take two options), continuous and unbounded or discontinuous and bounded? The application of the logical possibility space seems to warrant the assumption that the possibility space of universes is continuous and unbounded. To illustrate this consider again the charge of the electron. If we assume that this charge can hold a value equivalent to any real number and if each of these values corresponds to a possible universe then there are an infinite number of possible universes. But logical possibility space may not be the appropriate space. Logical possibility is certainly an option, but it is not the only option. It may be that logical possibility space simply does not correspond to what is 'really' possible. What is 'really' possible depends on the nature of ontic possibility space. It may be that ontic possibility space simply *is* logical possibility space. But alternatively, it may be that ontic possibility space is, for example, not continuous but discontinuous. For example, while it may be ontically possible for the charge of the electron to hold the value of  $1.602192 \times 10^{-19}$  or  $1.302192 \times 10^{-19}$  it may not be ontically possible for the charge to hold the value of  $1.402192 \times 10^{-19}$ , the ontic possibility space may be *quantised* in nature. Or alternatively, it may be *chaotic* in nature. If it is chaotic in nature then charges of electrons that are quantitatively very

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<sup>7</sup> Here I should stress that I am not necessarily assuming a classical interpretation of probability, where probability is defined in terms of possibility. I am simply claiming that in order for an event to have any non-zero probability it must also be possible.

<sup>8</sup> Leslie makes a distinct 'local area' argument that I will consider later, but his 'local area' is in logical possibility space.

close, may lead to electrons with very different qualitative natures. I will argue that this may explain why ‘slightly different’ universes preclude life.

#### *1.2.6 Is the fine-tuning improbable?*

Having considered the nature of ontic possibility space we can now consider the nature of the probability space of universes; and thus the probability of the fine-tuning. We now return to what might be considered the *conventional* fine-tuning debate. Much of this debate concerns the improbability (or otherwise) of the fine-tuning and related issues. The first issue is the determination of the appropriate probability space. Again physical probability space is inappropriate. If we take physical probability space to specify the probability of events *given* the laws and initial conditions of the universe we cannot use this to discuss the probability of the fine-tuning of these very laws and initial conditions.<sup>9</sup>

The next choice is logical probability space and this space predominates in the debate, (Leslie 1989) 138, (Swinburne 2004) 172. But, as is well documented in the literature, there are major problems determining the probability of the fine-tuning in this space. The first problem relates to the normalization of the space (McGrew, McGrew, and Vestrup 2001). To make probability statements about certain possibilities in a probability space all the probabilities of those possibilities must add up to one. The *normalization* problem is that, if we are considering logical probability space, then there is an infinite number of possibilities each (arguably) with some positive probability. Unless we employ infinitesimals these probabilities will sum to infinity, not one. This makes assigning a probability to the fine-tuned values problematic. A closely related problem, (again ignoring infinitesimals) is the *measure zero* problem, which is, that in an infinite probability space any point (or finite volume) will have a probability of zero (Holder 2001), (Colyvan, Garfield, and Priest *forthcoming*). Another problem for an infinite logical probability space is the *slight difference* problem. This relates to the fact that without a bounded range over which the values vary, there is no way to decide what

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<sup>9</sup> In this context, physical probability space is represented by a point in the logical probability space.

is a slight difference is as opposed to a substantial difference (Clifton 1991). All these problems relate to the technical challenges of applying probability theory to an infinite space.

These technical problems are enough to convince some that it is not possible to determine the probability of the fine-tuning in an infinite logical possibility space. But John Leslie, while acknowledging the existence of technical difficulties, argues that it is meaningful to consider the probability of the fine-tuning in logical probability space.<sup>10</sup> He refers to the idea that this universe may have undergone a 'phase transition' where the fine-tuned features were set indeterministically. Now, by hypothesis, *this* universe could only have undergone such a process once, but he argues, this does not mean that probabilistic talk is meaningless here. Further, he notes that much of current physics is *probabilistic* in nature and argues that if this creates technical problems for probability theory, then it is probability theory, not probabilistic physics that should be revised (Leslie 1989) 112. Here Leslie touches the issue of indeterminism that will be central to this thesis. If indeterminism is characterised as probabilistic, then it may well be that probability theory will need to be revised. Similar concerns about indeterminism (as understood as physical probability) motivated Hugh Mellor to argue that it is inappropriate to consider the fine-tuning as probabilistic. Mellor argued that the universe cannot have a physical probability because physical probabilities are generated by a physical 'chance set up' and the universe, by hypothesis, cannot have a physical 'chance set up' (Mellor 1973), (Mellor 2003). While the fine-tuning cannot have a physical 'chance set up' it may have an ontic 'chance set up'. This idea will be explored later in the thesis with respect to a possible indeterministic 'vacuum fluctuation' explanation.

But setting aside the technical difficulties with respect to infinities and the possibility of explanations based on an indeterministic 'chance set up' there are more straightforward problems with determining the improbability of a fine-tuned universe. Current physics tells us that slight differences in the laws and/or initial conditions of the universe would

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<sup>10</sup> Leslie may be relying on more than one interpretation of probability. At some stages he appears to be using a logical interpretation and at other times he appears to be using a form of physical probability.

mean that carbon-based life would not be possible. But, as noted by Gilbert Fulmer this does not reveal anything about substantial differences (Fulmer 2001). It may be that completely different laws and initial conditions also allow for life, but presumably not *carbon-based* life. Call this the 'ignorance of distant regions' problem. And importantly, if distant regions of the probability space are abundant with life-allowing universes, then the *improbability* of the universe being fine-tuned is called into question. Intuitions differ on this point. Richard Swinburne argues that for the fine-tuning to be evidence for God, life-allowing universes must be rare in the total probability space (Swinburne 2004) 185. But Leslie argues that it is only the *local area* of universe that is relevant to the fine-tuning debate, call this his 'local area' argument (Leslie 1989) 138. Leslie claims that there is still a meaningful sense of improbability in this universe being fine-tuned, even if almost all universes in distant regions in the probability space of universes allow for life. For Leslie it is not so much the life-allowing-ness of the universe that is improbable but the *fine-tuning* of this universe. It is the fact that the universe is *fine-tuned* for life that makes it improbable. To understand this point, consider a planet with one large continent surrounded by ocean with one small island some distance off shore. Now consider a meteor that, *by chance*, hits this planet. Leslie would argue that it is reasonable to say that it is improbable for it to have hit the island, even though it was not improbable for it to have hit land.

### *1.2.7 Partitioning the probability space, and isoprobability*

I will employ a different approach to the notion of improbability in the fine-tuning debate. My analysis is motivated by a point made by Michael Scriven, (some years before the recent rise of this debate), in relation to the properties of the Universe.

If we decide to throw a die ten times, then it is guaranteed that a particular one of  $6^{10}$  possible combinations of ten throws is going to occur. Each of them is equally likely; each of them is entirely distinct from each other possibility. And each of them, if we study it closely, has interesting properties (Scriven 1966) 129.

This observation prompted me to re-examine the notion of improbability. I argue that improbability is essentially a *relational* notion. For something to be *improbable* there needs to be something else that is *probable*, or alternatively for something to be

*probable* there needs to be something else that is *improbable*. But now consider an equi-probable situation in which all possible events are equally probable.<sup>11</sup> In order to have a meaningful sense of a probable, or an improbable event, some other event is needed, that is more or less probable than that event. But, in an equi-probable situation there are *no such events*. Take an ideally fair die, and consider the distinct events of the die landing any one of {1, 2, 3, 4, 5, 6}.<sup>12</sup> Each has a probability of 1/6, but what does it mean to say that any one event is improbable? If probability is considered a relational notion: in relation to *what other event* is the rolling of a 3 (say) improbable? I argue that in equi-probable situations, the concept of improbable (or probable) may not be meaningful. Such events certainly have numerical probabilities but rather than call these events either probable or improbable I call them iso-probable.

I further argue that the only way to generate a reasonable sense of probability (or improbability) in an equi-probability space is by creating what I call a *demonstrative* partition. This is a partition that separates 'this' from 'not this', {A,  $\neg$ A}. For example, the partition of the probability space {3,  $\neg$ 3}. With a demonstrative partition, in an equi-probable probability space, there may be a reasonable sense of probability or improbability, (subject of course to the probabilities of the partitions). But now consider the *justification* for the demonstrative partition. If the justification is based on objective criteria, then there is an objective sense of improbability. But if the justification is based on subjective criteria, then the sense of improbability is equally subjective.

Alternatively, *non-demonstrative* partition is of the following form, {A, B, C, D, ...}. For example, the partition of the probability space of a die that separates {1, 2, 3, 4, 5, 6}. I take the objectivity for this partition to be unproblematic.

If the probability space of universes is an equi-probable space then this has relevance to the question of whether the fine-tuning is improbable. If the space is partitioned using

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<sup>11</sup> The notion of equi-probability is an idealisation and has problems of its own. But for the sake of argument let me grant that an equi-probable situation is possible.

<sup>12</sup> Here I am ignoring other events such as the die not landing at all.

the demonstrative partition {life-allowing,  $\neg$ life-allowing} it may be that that life-allowing universes are improbable. (Subject of course to there being few life-allowing and many life-precluding universes.) But then consider the *justification* for the demonstrative partition. For the improbability of the fine-tuning to be objective, the justification for the demonstrative partition must be objective. But what makes the justification of the partition objective? There are certainly objective differences between life-allowing and life-precluding universes. Some allow for life and some do not. But what is it about this difference that justifies an objective demonstrative partition? Obviously there are subjective criteria. We are interested in this life-allowing universe because we need it to live in, and that is enough to justify a subjective demonstrative partition. But this will not support an objective demonstrative partition. Without objective justification the demonstrative partition is subjective and thus the improbability of the fine-tuning that this partition generates is equally subjective.

If we can objectively justify the demonstrative partition, then we have grounds for claiming that life-allowing universes are objectively improbable. But the only way that I can see to justify an objective demonstrative partition is to argue that life-allowing universes are objectively *significant* or objectively *valuable* in some sense. This raises contentious value issues that I will not attempt to resolve in this thesis.<sup>13</sup> The important point is, that in the *absence* of an objective justification for the demonstrative {life-allowing,  $\neg$ life-allowing} partition, I assume that the partition is subjective, and thus the fine-tuning is only subjectively improbable. In the absence of an objective demonstrative partition the only objectively justifiable partition is non-demonstrative. So, rather than the fine-tuning being improbable (based only on a subjective demonstrative partition), it is more reasonable to describe it as iso-probable (based on an objective non-demonstrative partition). In other words, if an equi-probable space is assumed, the fine-tuning is as probable (or as improbable) as any other possibility.

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<sup>13</sup> And even this analysis leaves unexamined the issue that *life-allowing* universes are not necessarily *life-ensuring* universes.

### 1.3 Indeterminism and Explanation

#### 1.3.1 Responses to the apparent improbability

From here, I move from the question whether the fine-tuning is improbable, to an analysis of the responses to this apparent improbability. Obviously, if the first part of the thesis has undermined the ‘improbability’ then a positive reason is needed to continue the discussion. To deepen understanding of the issues I will persevere with the analysis, and assume that the fine-tuning can meaningfully be considered as improbable in some sense. To facilitate this analysis I separate the responses into two types. One type *rejects* the improbability by attempting to ‘explain it away’, while the other type *accepts* the improbability. Consider some examples of these two types of response. (I will explore them in more detail later in the thesis.)

Some look for *necessity* in the laws and initial conditions. This is the motivation behind the search for the ‘complete unified theory’ (Hawking 1989) 132. This response rejects the improbability by suggesting that the fine-tuned features ‘had’ to be the way they are. However, while this necessity may in fact obtain, we do not as yet have such a theory, so I will not explore this response in detail. Another response to the apparent improbability of this universe is to suggest the existence of many other universes with different values for the fine-tuned features (Rees 2003). If there are many other universes, all with different tuning (that may or may not allow for life), then it is no longer improbable that one of those universes would allow for life. Others have suggested that the fine-tuning is evidence for God (Swinburne 1990). The fine-tuning may well be improbable in the absence of God, but if we assume that God wanted the existence of intelligent organisms, then it is reasonable to assume that God would structure the universe in such a way as to allow for their existence.<sup>14</sup> So the assumption that God designed the universe would remove the improbability of the fine-tuning. Still others have suggested that the fine-tuning is evidence for *either* a ‘multiverse’, or God *or both* (Leslie 1989).

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<sup>14</sup> For the purposes of this thesis I will assume, that if God exists, then it is reasonable to assume that God could want the existence of intelligent organisms (why God would, is beyond the scope of this thesis).

Presumably there is nothing stopping God creating a 'multiverse'. All these responses can be considered as attempts to *reject* the improbability of the fine-tuning. But rejection of the improbability is not the only option.

Another response is the simple acceptance of the improbability of the fine-tuning as 'the way things are'. One such response simply accepts this fine-tuned universe as among the logically possible universes. When considered in logical possibility space the fine-tuning is *accepted* as improbable. This 'explanation' of the fine-tuning is simply to say that it was due to chance operating in logical possibility space (Scriven 1966) 129. However, some find such an 'explanation' unsatisfying. Some feel that chance operating in logical possibility space is simply *not* an explanation. Or, at the very least, it seems that *more effort* could be made with respect to the explanation. The sense that more could be done motivates the responses that attempt to reject the improbability. While I agree that more could be done, I do not agree that rejecting the improbability is the appropriate response to the fine-tuning. I propose a response that does not reject the improbability. I am motivated by the fact that current science has accepted indeterminism. I propose to explain the fine-tuning using it. Perhaps this universe is the isolated outcome of an ontic process related to the quantum field.

### *1.3.2 Indeterminism*

To understand indeterminism, consider the half-life of a Carbon 14 atom. There is a 50% probability that a single Carbon 14 atom will decay in a period of 5730 years (Salmon et al. 1992) 31. Now consider the actual decay of a Carbon 14 atom in a relatively short time interval, say one hour. This event has a very small probability of occurring. However, if we observe this very improbable event we are not motivated to explain away this improbability by changing our minds about the explanation of the event. We simply accept that an improbable event has occurred. However, this approach of accepting improbable indeterministic events is in direct conflict with the broader explanatory principle that we like explanations to make events probable. To understand this broader explanatory principle, compare the intuitive appeal of explanations that

make events probable with the intuitively unappealing nature of explanations that leave events as improbable<sup>15</sup> But if we intuitively favour explanations that raise the probability of that which they explain, while at the same time we accept the reality of indeterminism then we may be lead into error. Consider the case of the decaying Carbon 14 atom. If we are inclined to accept explanations that raise the probability of the event then we may be inclined to believe that the atom was in fact *not* Carbon 14 at all, but rather an atom of a more radio-active element, such as Thorium 234 with a half life of 24 days. This simple example illustrates that indeterminism has important implications for the way we use probability in explanation in general and in explaining the fine-tuning in particular.

### *1.3.3 Probability and explanation*

To begin my analysis of explanation, I consider what makes a good explanation. There are several criteria, but that of central importance to this thesis relates to the fact/foil distinction (Lipton 2000) 188. Explanations are often considered to be answers to 'why' questions. But explanations can be further considered as not only answers to 'why this' questions but also answers to 'why not that' questions. Explanations are considered 'good' when they tell us why 'this' happened (the fact) as *opposed* to 'that' (the foil). Unfortunately, indeterminism denies us explanation of the foil. Current science can tell us why atoms decay, but cannot tell us why an atom decayed at  $t^1$  as opposed to at  $t^2$ . Current science says that there is simply no explanation.<sup>16</sup> We can stipulate the probability of the atom decaying at  $t^1$  (i.e., in a finite time interval) but the explanation will be the same whether or not the atom decays. This is the central problem facing the explanation of indeterministic events.

I will examine scientific explanatory strategies, including the probabilistic causal model of Mellor, with reference to indeterminism. Mellor argues that causes 'raise' the chances

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<sup>15</sup> One intuitively appealing explanation of footprints on a beach is that a person has recently walked along that beach. Another intuitively unappealing explanation is that a cow wearing boots has recently walked along that beach (Fumerton 1992) 207.

<sup>16</sup> Here I am bracketing confounding factors such as atomic bombardment.

of their effects (Mellor 1995) 67. This ties in with his (correct) view that we *want* our explanations to “raise the probability of what they explain” (Mellor 1995) 75. But although we might *want* our explanations to raise the probability of what they explain this can lead into error. Strictly speaking we *do not want* our explanations to raise the ‘probability’ of events *above* the ontic probability of those events. We want our explanations to generate epistemic probabilities that *match* ontic probabilities. This leads me to propose an explanatory maxim of *conformity* or the ‘conformity maxim’.

*Explanans should generate epistemic probability distributions that conform to the ontic probability distributions of the explananda.*<sup>17</sup>

#### *1.3.4 Probability and explanation choice*

I then proceed to consider the relation of indeterminism to explanation *choice*, with specific reference to how probability influences choice between explanations. This is centrally relevant to the assessment of the possible explanation of the fine-tuning, as an isolated outcome of an indeterministic process. I consider so-called ‘self-evidencing’ explanations. A self-evidencing explanation is such that “the phenomenon that is explained in turn provides an essential part of the reason for believing that the explanation is correct.” (Lipton 2000) 185. This is one way to characterise Inference to the Best Explanation and also what I call Leslie’s ‘neatness principle’. Leslie claims that; “A chief reason for thinking that something stands in special need of explanation is that we actually glimpse some tidy way in which it might be explained.” (Leslie 1989) 121. This idea of self-evidencing is also central to confirmation theory and I will analyse it in detail.

One key idea of confirmation theory is that if a hypothesis makes certain evidence more probable then the hypothesis is itself more probable. This is problematic in relation to isolated indeterministic cases. Consider the case of the decaying atom of Carbon 14. Theoretically, if the atom were in fact Thorium, then this would make the decay more

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<sup>17</sup> Again remember that I am using the term ‘epistemic probability’ differently to how it has been used in the probability literature.

probable. But this is not a good reason to conclude that the atom is more likely to be Thorium. Take the isolated decay of an *unidentified* atom in the next hour. This isolated decay event may be the improbable decay of a Carbon 14 atom or it may be the more probable decay of a Thorium 234 atom. But on the sole evidence that an unidentified atom has decayed there is no way to choose between these two hypotheses. Sometimes improbable events happen, and sometimes probable events happen. Admittedly probable events happen more often than improbable events, but in the case of an isolated event there is no "often"; there is only one event. The only way that confirmation theory works for isolated events is to *assume* that the isolated event is a probable event. If we assume that the event is probable, we can use confirmation theory to show that the hypothesis that makes this event probable is itself probable. But this is circular. We assumed that the event was probable and in the case of an isolated indeterministic event we have no justification for making this assumption. This leads to a tension between confirmation and the pursuit of truth in the explanation of isolated indeterministic events. It may be understandable to believe that isolated indeterministic events are probable and thereby choose to believe the hypothesis that confirms this probability but we have no rational justification for so doing. There is no way of establishing the probability of an isolated indeterministic event *based only on the event's isolated occurrence*. Isolated indeterministic events may be probable and happen to occur or may be improbable and happen to occur.<sup>18</sup>

### *1.3.5 Explanation indication*

The second part of the thesis proceeds in terms of an analysis of the responses to the fine-tuning. But I have not considered the *motivation* for these responses. These responses have been explanations of various sorts and most involve an attempt to 'explain away' the improbability of the fine-tuning. But why are we required to explain the fine-tuning at all? Leslie considers this question and concludes that we need to explain the fine-tuning (or to explain life, as he puts it) because we can think of a tidy

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<sup>18</sup> The conformity maxim does not help here because an isolated event conforms equally to all hypotheses that give that event a non-zero probability of occurring.

explanation (Leslie 1989) 121. Others in the debate are less clear about what triggers the need to explain the fine-tuning but nonetheless are strongly motivated to do so. Davies wants to know what the universe is 'about' (Davies 2003).

Improbability *per se* is not *sufficient* to trigger the need to explain an event (although it might be *necessary*). This is generally accepted, both in the fine-tuning debate (Leslie 1989) 115, and more generally, with respect to any improbable event (Horwich 1982) 101. To understand what triggers the need to explain the fine-tuning I consider four approaches to explanation indication, these being: significance, surprise, specification, and analogies.

First, consider significance. Perhaps the fine-tuning is very improbable. If this is the case, then life is also very improbable. Many feel that life is significant. But the improbability of life may *contradict* the significance of life. This is based on the assumption that 'significant' things cannot be improbable. Perhaps this means that the existence of life cannot be improbable. I will argue that *objectively* significant things *cannot* be improbable, but that *subjectively* significant things *can* be improbable. I will not attempt to determine whether a universe that allows for life is objectively or subjectively significant. However I claim that the objectivity of the significance of life has not been established, and thus significance together with improbability is not sufficient to trigger the need to explain the fine-tuning.<sup>19</sup>

Second, consider surprise. Some argue that the fine-tuning is surprising. Paul Horwich considers the notion of surprise in detail (Horwich 1982) and I will analyse his work in the light of my consideration of the impact of indeterminism on explanatory strategies. Horwich's approach relies on the symmetry of the probability calculus, but I will argue this symmetry is problematic when applied to isolated events in indeterministic systems. I argue that if the fine-tuning is an isolated outcome of an indeterministic system, then it should not be surprising. Relying on the conformity maxim, I argue that only events that do not conform to the probability distribution associated with their current explanation

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<sup>19</sup> If objective significance is assumed then this begs the question.

should be surprising. Given that an isolated event conforms to every explanation that gives it a non-zero probability of occurring, the fine-tuning cannot be surprising; to be surprising it would need to be impossible. This is a development of the argument previously presented by Scriven that explanation is only required in a chance situation if the outcome is *contrary* to chance (Scriven 1966) 129.

Third, consider specification. Here I concentrate on the work of William Dembski (Dembski 1998). Dembski's work and the term 'specification' are not widely associated with the fine-tuning debate. However, the notion of specification is implicit in Leslie's 'neatness principle' (Leslie 1989) 121. Dembski developed the *explanatory filter* and he uses it to draw inferences about design. The central notion of Dembski's *design inference* is that "specified events of small probability do not occur by chance" (Dembski 1998) 5. A specification is a description of an event that is independent of the occurrence of the event itself. For example, imagine writing down a series of 100 H's or T's to describe a series of coin tosses. Then imagine tossing a coin one hundred times. If the coin lands in the order specified, then, Dembski argues, this is a specified event of small probability and we can infer design (or more precisely, we can eliminate chance). This is to be contrasted with fabrication. A fabrication is a description of an event that is not independent of the event. For example imagine first tossing the coin 100 times, then writing down the series of H's and T's based on the outcome. This is clearly a case of fabrication. Fabrication plus small probability does not eliminate chance. Dembski suggests that the fine-tuning is a specified event of small probability and thus we can infer design (Dembski 1999). I consider the application of the explanatory filter to the fine-tuning debate and argue that (ignoring fortuitous chance 'specification' or presupposing that which is to be inferred) any description of the fine-tuning must be a fabrication, and thus chance is not eliminated.

Fourth, consider analogies. Many analogies are used in an attempt to demonstrate that the fine-tuning requires explanation (Leslie 1989) 121, (van Inwagen 2002) 161. Situations are presented as analogous to the fine-tuning and as requiring explanation. Thus *by analogy* it is claimed the fine-tuning requires explanation. The role of analogies can be clarified by considering Dembski's notion of specification. I use the distinction

between specification and fabrication to argue that all the analogies fail, because they are not genuinely analogous. While all the 'analogues' are specifications, and thus require explanation, they are not genuinely analogous to the fine-tuning, so they do not demonstrate that the fine-tuning requires explanation. I argue that the description of the fine-tuning is a fabrication. The only ways to specify the fine-tuning are either to assume specification in the mind of God (which, presupposes God's existence and thus begs the question) or to demonstrate that the fine-tuning is necessarily specified in some form of mathematical structure (and this would be a 'theory of everything' that we currently do not have).

### *1.3.6 Explaining the fine-tuning*

For argument sake grant that the fine-tuning requires explanation. I will examine the possible explanations. First I consider the *multiverse* explanation. Traditionally the universe is taken to refer to all of material existence. But here the universe is but one of many distinct regions or domains within what has been termed the 'multiverse' (Davies 2004). If there are many other universes with different values for the fine-tuned features, then we can reasonably expect at least one of these to allow for life. This, together with the fact that we must be in a universe that allows for life (because we could not be in any other), explains why this universe is fine-tuned for life. The existence of many such universes removes the improbability that at least one would allow for life. The central criticism of this explanation is that the postulation of many other universes does not remove the improbability that *this* universe is fine-tuned (White 2000). This criticism rests on the assumption, implicit in confirmation theory, that explanations should raise the probability of the events they explain. But as I argue throughout this thesis if we assume indeterminism, it is not appropriate to assume that an explanation should necessarily raise the probability of the events it explains. Rather an explanation should generate an epistemic probability distribution that matches the ontic probability distribution of the events (or event) it explains.

Second I consider the design explanation. This explanation rejects the improbability, and proposes that the fine-tuning is due to God (Swinburne 1990). Although the fine-tuning may be improbable in the absence of God, if we assume that God exists and wants the

existence of intelligent life, then it is to be expected that God would structure the universe in order to allow for life. Thus God's designing influence would remove the improbability of the fine-tuning, and in so doing explain it. There is a large philosophical literature relating to design arguments and the nature of God, with which I do not directly engage. For the purposes of this thesis I set aside the traditional criticisms of the design argument, for example (Hume 1969) and I take God to be the theistic God as defined by Swinburne (Swinburne 1991) 8.

However, I present a criticism of the design explanation for the fine-tuning that has some parallels with the traditional 'problem of evil'. I call it the 'problem of contingency' and it is related to the apparent fact that the existence of intelligent (carbon-based) life is not *certain* given the fine-tuning of the universe. I argue that if the traditional theistic God wants the existence of intelligent organisms, then the existence of those intelligent organisms must be certain. I consider this problem and possible solutions and I argue that the best way to avoid this problem is to assume that God does in fact ensure the existence of intelligent carbon-based life by creating a world based on apparently indeterministic laws and then acts through those laws to ensure the existence of intelligent organisms.

The final explanation examined is that this fine-tuned universe is the isolated product of an indeterministic process. This explanation is motivated in part by the realization that if God acted through indeterminism to ensure the existence of intelligent organisms, this action would be *empirically indistinguishable* from indeterminism acting *without* God's intervention. So it is simpler to deny God's involvement and assume that this universe is the isolated improbable outcome of an indeterministic process. This explanation is further motivated by the fact that current physics supports the notion that the laws of nature were set by a 'symmetry breaking' process. The values of the fine-tuned features of this universe may not be fundamental but accidental, just as the actual crystal structures that form on the surface of a frozen pond are not fundamental to the nature of water but are accidental (Rees 2003). Most writers proceed from the ideas of 'symmetry breaking' to the assumption that such an accidental process has occurred many times (this being the basis of the 'multiverse' explanation) but I will argue that this is not

necessary. If we can specify a suitable indeterministic process that could generate the fine-tuning then we have an explanation. We do not need to postulate the existence of other universes.

In the analysis of this explanation, I start with the suggestion made by Edward Tryon (Tryon 1990) that this universe could be the product of a quantum vacuum fluctuation and use the work of (Smith 1986) to argue that the fine-tuning of this universe could be the outcome of a single symmetry breaking. If we reject the principle of sufficient reason (as indeterminism demands), and accept the possibility that this universe is improbable, then we have a suitable explanation of the fine-tuning without postulating other universes or God. Once we have a well-specified indeterministic process that could have generated this fine-tuned universe, we have an explanation of it. Of course this process *may* have produced other universes; but the existence or non-existence of other universes is completely independent of the explanation of this universe, just as the existence of a lottery and the fact that I bought a ticket, explains (with a certain probability) why I won. But this explanation in no way implies the existence of winners of other lotteries or the rigging of this lottery.

### *1.3.7 Choosing a response to the improbability of the fine-tuning*

We can *reject* the improbability and decide that God fine-tuned the universe. Or we can *reject* the improbability and decide that there are other universes.<sup>20</sup> Alternatively, we can respond by *accepting* the improbability and decide that this universe is one of the logically possible universes and thus nothing more needs to be said. Or we can *accept* the improbability and decide that the universe is the isolated outcome of an indeterministic process. Employing epistemic conservatism I avoid the postulation of unnecessary entities (other universes or God), and I use what we have good reason to believe is the structure of this universe to argue that the fine-tuning is the outcome of an isolated indeterministic process possibly grounded in a chaotic or quantised ontic state.

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<sup>20</sup> Although some will argue that there is no justification for assuming the existence of other universes, because this assumption has not made this universe any more probable.

## 2 Cosmological Physics

### 2.1 Some preliminary remarks

I will present an account of the origins of the universe.<sup>21</sup> But some preliminary remarks are necessary. This thesis is predominantly concerned with philosophy. While an understanding of the physics is necessary, it is not the central focus. The physics is intended to complement the philosophy, not overwhelm it. This chapter presents an overview of current cosmological physics. I use the word 'current' advisedly. Articles concerning the fine-tuning of the universe are common both in popular science and academic journals. No doubt the best cosmological theories face revision. I seek as far as possible to present the current theories, knowing that these will change. Given the physics as I present it, I then embark on philosophy. Much of the relevant physics is atomic particle physics, and it is complex. For the purposes of this discussion I limit myself to basic cosmological physics involving the four fundamental forces and four elementary particles.

#### 2.1.1 *Four elementary particles*

Let me start with the particles: the proton, the neutron, the electron and the neutrino. These particles can exist as independent particles or as combinations of particles. Atoms are arrangements of protons (and usually neutrons) in the nucleus, with electrons surrounding that nucleus. However protons and neutrons may combine without associated electrons. Protons are positively charged and are large subatomic particles, having a mass of 938.26 MeV. Neutrons have no charge and are approximately equal to the mass of a proton, having a mass of 939.55 MeV. Protons and neutrons combine to form the nuclei of atoms. The electron is negatively charged and has the same magnitude of charge as a proton. The electron mass is 0.511 MeV, and so the electron is approximately 2000 times less massive than the proton. Electrons in atoms can be

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<sup>21</sup> The information relating to the origins of the Universe has been compiled from the following works: (Pirani 1999; Uvarov, Chapman, and Isaacs 1982; Leslie 1989, 1990; Hawking 1989; Davies 1993; Gribbin and Rees 1991).

thought of as surrounding the nucleus. The neutrino is an elementary particle with no electric charge or rest mass. The neutrino is involved with several subatomic processes including beta decay.

### *2.1.2 Four fundamental forces*

There are four fundamental forces of nature. These are the nuclear strong force (NSF), the electromagnetic force (EMF), the nuclear weak force (NWF), and the gravitational force (GF). The NSF is an attractive force that operates on nucleons (protons and neutrons). It acts over very short distances, shorter than  $10^{-15}$  m. This force is responsible for holding atomic nuclei together. The NSF is approximately  $10^2$  times stronger than the EMF. The EMF is a force that operates between electrically charged elementary particles, protons and electrons. It is a repulsive force between particles of the same charge and an attractive force between oppositely charged particles. The EMF is approximately  $10^4$  times stronger than the NWF. The NWF is a force between elementary particles and is associated with various particle transformations, (including those involving neutrinos). The NWF is  $10^{31}$  times stronger than gravity. GF is an attractive force that exists between all matter.

While for the purposes of this discussion I take these forces to be fundamental, note that current theory suggests that these forces may not be as fundamental as previously assumed. According to one interpretation, these forces have resulted from a process of 'symmetry breaking'. On this interpretation the specific values of the forces are not 'fundamental' but rather they are accidental (Rees 2003).<sup>22</sup>

### *2.1.3 The assumptions of modern cosmology*

Cosmology is the study of the universe as a whole. Obviously we only have direct contact with our local region of the universe. If we are to study the whole universe we

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<sup>22</sup> Alternatively, Hawking characterises the division into the four forces as imposed by physicists to facilitate the construction of theory. Hawking hopes that a unified theory will explain all four forces as different aspects of a single force (Hawking 1989) 74.

need to make certain assumptions about the nature of the universe beyond our local region. Modern cosmology is based on three central assumptions. These are: (a) atomic particles that exist in our region of the universe exist throughout the rest of the universe; (b) the laws of nature that apply in our region apply throughout the rest of the universe; and (c) the laws that apply in the present also applied in the past (Pirani 1999) 63. If any one of these assumptions is incorrect then the accuracy of modern cosmology is called into question. A simple way of putting this is via the general assumption that the portion of the universe that we observe is 'representative of the whole'. This general assumption is known as the Copernican principle (Davies 2004). Using these assumptions, cosmologists have constructed a theory concerning the origins of the universe.

#### *2.1.4 Understanding the term "fine-tuned"*

What does 'fine-tuning' mean? Robin Collins suggests that a parameter is fine-tuned if

the range of values,  $r$ , of the parameter that is life-permitting is very small compared with some non-arbitrarily chosen theoretically "possible" range of values  $R$ . The degree of the fine-tuning could then be defined as the ratio of the width of the life-permitting region to the comparison region (Collins 2003) 179.

Further, Collins distinguishes the notion of 'one sided' fine-tuning from 'two sided' fine-tuning. One sided fine-tuning is the situation in which a small change in one direction of the value  $r$  will result in a life-precluding universe but a similarly small change in the other direction will not. To illustrate this imagine a rock resting close to the edge of a cliff. Move the rock a small distance one way and it will fall off the cliff, but move it a small direction the other way and it is further from the cliff edge. By contrast, two sided fine-tuning is the situation in which a small change in either direction of the value  $r$  will result in a life-precluding universe. To illustrate this imagine a rock resting on top of a rock pillar not much bigger than the rock itself. Collins further notes that in many cases of fine-tuning we only have reason to believe in one-sided fine-tuning but none the less many people interpret even one-sided fine-tuning as significant. Taken together all the fine-tuning is seen by many as surprising.

During this review of cosmology it should be remembered that much of the fine-tuning

is concerned with the interrelations between the various fine-tuned aspects of nature. To a large extent, it is these interrelations that create the fine-tuning. It should also be borne in mind that these interrelations can be considered from different perspectives. These relations depend on the fine-tuning of more than one aspect of the universe. So the fine-tuning can be understood by considering how the change of one value would affect all the others, or by holding that one value constant while we consider the result of changing another value. However, it should always be remembered that fundamentally, it is the fine-tuning of the *interrelation* among the values that is of central significance.

Finally, it is possible that not all these cases of fine-tuning are correct. Collins examines problems associated with the apparent fine-tuning of the NSF, gravity and the proton-neutron mass difference (Collins 2003). Advances in cosmology may remove the apparent fine-tuning. But for the purposes of this thesis I will accept that the universe is fine-tuned for life.

## **2.2 The origin of the Universe**

### **2.2.1 In the beginning...**

This account begins with the creation of the physical universe. For our purposes I assume that certain laws that govern this universe are in operation; for example the laws associated with quantum theory. This account does not explain the existence of these laws, but accepts them as a starting point. From this starting point the rest of the universe can be explained. To begin, there is no physical universe, no matter or energy and no space-time, but the laws of quantum mechanics are in place.<sup>23</sup> Quantum mechanics operates at very small scales. At very small scales quantum fluctuations can create energy/matter and the space-time for it to exist in. The account begins with a quantum fluctuation that brings into existence all the mass-energy of the observable universe in a space the size of a proton.

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<sup>23</sup> The use of temporal language here should be taken not literally, but metaphorically, and is used only for grammatical convenience.

One possible conception of the origin of the material universe is that 'something' comes out of 'nothing'. But this is not accurate. Peter van Inwagen uses the analogy of a fist to illustrate the quantum vacuum (van Inwagen 2002) 131. The quantum field exists, just like a hand exists. A hand can be in various states, one of them being a fist.

Analogously, the quantum field can be in various states, one of them being the vacuum state, another being a vacuum fluctuation. Thus something does not come out of nothing.

Rather the quantum field can be in the state of vacuum fluctuation. In the case of the origin of the universe, matter/energy comes into existence, but at the same time, so too does antimatter/negative energy. Although matter and energy seem to be created they are only part of the equation. If the complete process is considered then the total is zero.

Hawking describes the situation as a balance of positive and negative energy, such that the "total energy of the universe is exactly zero". Matter can be considered as positive energy (by  $E=mc^2$ ) and the gravitational force that exists between matter can be considered as negative energy (Hawking 1989) 316. These two energies cancel each other out. So now there exists a large amount of matter/energy (albeit ultimately cancelled out by antimatter/negative energy).

### *2.2.2 The inflationary phase*

The next step in the process is the expansion of this matter and energy leading to a much larger space. This expansion occurred in a very short time, between  $10^{-35}$  seconds and  $10^{-30}$  seconds after the quantum fluctuation. The universe doubled in size approximately every  $10^{-34}$  seconds. This phase increased the size of the universe from the size of a proton to about the size of a basketball (Gribbin and Rees 1991) 271-91. This phase is referred to as the inflationary phase. There are various versions of the inflationary model of the universe. The first was presented by Alan Guth in the early 1980's and subsequent adjustments have refined this theory. However no definitive theory of inflation has gained broad acceptance. Hawking has most confidence in the 'chaotic inflationary model' proposed by Andrei Linde in 1983 (Hawking 1989) 139. The basic idea of all inflationary models is that the normally *attractive* force of gravity is a *repulsive* force for a period of time in the early moments of the universe and during that time the universe expands at a very high rate. Each version of the inflationary model gives different

reasons for this repulsive nature of the force of gravity. Guth's original theory relied on a sudden phase transition or symmetry breaking where the four forces, the nuclear strong, nuclear weak, electromagnetic and gravity, precipitated out of one more fundamental unified force. Linde then proposed an alternate version of inflation with slow phase transition, but has since suggested the 'chaotic inflationary model'. The details of these different theories are not important to this thesis. As mentioned above, the common feature of all of them is that the 'normally' attractive force of gravity is initially a repulsive force and it inflates the universe. The period of inflation ends with the conversion of the force of gravity to an attractive force.

The inflationary model is considered by many to have explained some of the fine-tuning of the universe. Before the inflationary model of the universe became accepted there were the following two concerns. The first is the 'smoothness' problem. The smoothness of the universe is the way that matter is distributed in the universe. If the universe were more or less 'lumpy' than it actually is, then stars and planets would not have formed. Had it been less lumpy the gravitational attraction of matter would not have been strong enough to create massive bodies; more lumpy and the gravitational attraction would have resulted in a universe composed only of black holes. The second is the 'flatness' problem. For the universe to be as 'flat' as it is today, the initial rate of expansion of the universe would need to be a very specific value. This critical value has been called the fine-tuning of the expansion rate of the universe. However the inflationary model appears to explain how many different expansion rates of the universe would all end up looking much like the universe we now live in (Hawking 1989) 140. So, specifically in relation to the fine-tuning of the speed of expansion of the universe, advances in physics have removed the need for fine-tuning. In fact a prime motivation for the development of the inflationary model was to explain this 'fine-tuning'. Of course, this is only one example of fine-tuning and there are many others that have no current explanation.

However, the development of the inflationary model indicates that as physics progresses we may understand more about other apparently finely tuned aspects of our universe.<sup>24</sup>

The early moments of the universe considered so far, including the quantum fluctuation and the inflationary period, are very brief indeed. But important events occurred in this very short time. Although there were still major differences, many aspects of the universe were as they operate today. Matter and energy both existed and the four forces were operating as they do today. The values of the four fundamental forces and the masses of the elementary particles were very important in dictating the composition of this early universe. Whether a primordial baryon became a proton or a neutron in this early universe was dependent on the interaction of their masses and the NWF. Had the mass difference between the proton and the neutron been greater, then all neutrons would have decayed into protons, meaning that the only possible element in the universe would be hydrogen. Alternatively, had the mass difference been smaller by  $1/3$ , then all protons would have become neutrons. The existence of both protons and neutrons is necessary to produce nuclei larger than one proton. The attractive NSF between two protons is not enough to overcome the repulsive EMF of the (like charged) protons. However, while the neutron is electromagnetically neutral, it still has the attractive NSF. So if a number of neutrons combine with protons the attractive NSF of the neutrons adds to the attractive NSF of the protons without adding to the repulsive EMF and this makes possible the combination of these particles into a nucleus. The value of the proton-neutron mass difference allows for the existence of the elements that form the foundation of chemistry and biology. The proton-neutron mass ratio and the strength of the NWF ensured that the early universe was composed predominantly of protons with a lesser number of neutrons. This early predominance of protons led to the later universe being composed of 70% hydrogen (Leslie 1989) 34-39.

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<sup>24</sup> However the process of inflation itself appears to be dependent on the fine-tuning of another value, the cosmological constant. But developments in the 'chaotic boundary conditions' proposal may in turn remove this fine-tuning (Hawking 1989) 129.

### *2.2.3 After inflation*

After the inflationary period, the universe still expanded very rapidly, not as rapidly as in the inflationary period, but rapidly nonetheless, and although expanding, it was still very hot and dense. About one second after the quantum fluctuation, its temperature was ten thousand million degrees (Hawking 1989) 123. This highly energetic state affected the arrangement of matter. The particles that existed in this early universe were protons, neutrons, electrons, and neutrinos. It also contained a large amount of energy. Although the four fundamental forces operated in this early hot dense universe, the particles moved too fast to form the atomic structures that are familiar today. For example, electrons were not associated with protons and neutrons, so there were no 'atoms' as yet.

As the universe continued to expand and cool, the energy of the particles dropped and the action of the four forces resulted in the formation of atomic structures. Two important possibilities here were di-protons and deuterons. Di-protons are comprised of two protons, and deuterons are composed of one proton and one neutron. At about 100 seconds after the quantum fluctuation, the temperature of the universe was around one thousand million degrees. At this temperature the attractive NSF was powerful enough (in relation to the kinetic energy of individual protons and neutrons) to combine them into nuclei of deuterium (a deuteron). Just how protons and neutrons combined in the early universe was affected by the strengths of the NSF and the EMF. The di-proton is a proton-proton pair whose stability is dictated by the balance of the repulsive EMF and the attractive NSF. The ratio of these forces is such that collisions of protons rarely results in the formation of di-protons. However, in the case of the stability of deuterons, the repulsive EMF is not in effect, deuterons being a combination of protons and neutrons (neutrons are charge neutral). So deuterons succeed in binding.<sup>25</sup> The lack of di-protons in the universe is important because had the proton-proton bond been more stable there would have been no free protons that could later form hydrogen. The

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<sup>25</sup> Weakening the NSF by 5% would unbind the relevant bond. If this were the case no deuterons would form and hence no elements with more than one nuclear particle. This would yield a universe of hydrogen only. Conversely, a 2% decrease would mean all protons would bind as di-protons so there would be no potential for hydrogen at all (Leslie 1989) 36.

presence of deuterons is also important. Deuterons are essential to the process of stellar nucleosynthesis (see below).

The process of particle combination included further combinations of various individual particles to produce helium, lithium and beryllium nuclei. Calculations indicate that in this period, one quarter of the primordial baryons (protons and neutrons) existed as helium nuclei (alpha particles), a small number existed as deuterium nuclei and the remainder of the neutrons decayed into protons. At this stage 99% of the matter in the universe was hydrogen nuclei (protons) and helium nuclei. This process continued for several hours and then stopped (Hawking 1989) 124.

#### *2.2.4 Stellar nucleosynthesis*

For the next million years the universe continued to expand without the structural relations of the particles altering. Once the temperature dropped to a few thousand degrees, the kinetic energy of individual particles was not sufficient to overcome the attractive force of electromagnetism and so electrons became associated with the nuclear particles and atoms formed. Up to this point the structure of the matter in the universe was dictated by the interaction of the temperature of the universe, and the four fundamental forces. This interaction created atomic nuclei, and then later, atoms - but only with small atomic numbers. The next phase of the development of the universe concerned the production of larger atoms and for this to occur stars were necessary.

The universe continued to expand, but the density distribution of matter was not perfectly even and regions that were slightly more dense began to contract under the mutual attraction of gravity.<sup>26</sup> As this happened, due to other gravitational influences, they also began to spin. The spinning continued as the collapse progressed and interaction of these effects created solar systems and galaxies. The gravitational force of these regions collapsed the matter into what became stars, and the temperature of the cores of these proto-stars increased. This heat increased the energy level of the particles

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<sup>26</sup> This uneven density is the critical value of 'smoothness' mentioned above.

in the core. So the balance between the energy of the particles and the four fundamental forces returned to a state in which changes could occur in the arrangement of these particles. The change that occurs in the core of stars is called stellar nucleosynthesis (Gribbin and Rees 1991) 241-91.

Before stellar nucleosynthesis, the general temperature of the universe created hydrogen (and deuterium), helium and lithium from the primordial baryons (protons and neutrons). All elements heavier than lithium are produced inside stars by nuclear fusion. In this process smaller nuclei combine and fuse to form larger nuclei. The process may involve the combination of nuclei and the release of smaller particles and energy. For example, two deuterium nuclei (D) fuse to form helium (He) with the release of a neutron (n) and energy (MeV) in the following fusion reaction:  ${}^2_1\text{D} + {}^2_1\text{D} \rightarrow {}^3_2\text{He} + {}^1_0\text{n} + 3.27 \text{ MeV}$  (Warren 1983) 175. This process is driven by heat and pressure created in the central core of stars; the larger the star, the greater the heat and pressure. Generally, more energy is required to fuse larger nuclei than to fuse smaller nuclei. Fusion in the core of a star begins with hydrogen and may continue up to the creation of iron. How far the process of nucleosynthesis progresses depends on the mass of the star. The more massive the star the further through the chain of fusion reactions the star progresses. Generally, as fusion takes place the star is in hydrostatic equilibrium, where the energy created supports the mass of the star from collapsing under the force of gravity. If fusion stops with the exhaustion of a certain element, the star will begin to collapse. This may end the fusion process and the star simply cools. However if there is enough mass in the star, the gravitational collapse will once more create heat and pressure in the core. If this heat and pressure is sufficient to raise the temperature of the core to a level that triggers the burning of another element, then fusion to the next element commences.

As described, the matter of the universe began to form stars. The hydrogen, compressed in the core of stars, began to 'burn' to form helium. This process started with the combination of a proton and a neutron to form a deuteron. Two deuterons then combined to form a helium nucleus. The fundamental process of nucleosynthesis is a combination of multiples of helium. Helium contains 2 protons and 2 neutrons and as such is very stable. Nuclei that are multiples of helium (with the exception of beryllium) are also

very stable. Thus the heavier elements are created by the combination of multiples of helium. Note here that the formation of deuterons depends on the value of the NSF. If the NSF had a value 5% weaker than it does, deuterons would not form (Leslie 1989) 36. Without deuterons, there would be no subsequent formation of helium and hence no production of heavier elements. Elements that are not multiples of helium are created when elements that are multiples of helium subsequently decay and release smaller particles. The process of combination of helium nuclei (alpha particles) depends on the particles coming together with the appropriate energy. This process occurs due to a characteristic of nuclei known as 'resonance'.

#### *2.2.5 Resonance*

Electrons occupy different energy levels, called electron shells, around a nucleus. Nuclei have a similar set of energy levels and these are quantised just as electron shells are. These energy states can be thought of as 'resonances'. Nuclei can be found in differing energy states, and nuclei can jump between energy states. A nucleus in its lowest energy state may be excited into higher states. The creation of a larger particle succeeds if smaller particles combine in such a way as to create the amount of energy that matches one of the energy states of the (potential) larger particle. The amount of energy in the process is the sum of the energy of the states of the particles themselves and the kinetic energy of their motion. If this combined energy is equal to (or slightly larger than) one of the resonances of the potential larger element then the larger element forms. In the case where the combined energy is slightly larger, this excess energy can be emitted or alternatively a particle can be emitted. But if the combined energy is lower than the nearest resonance levels of the potential element, the fusion will not occur. So the success of fusion depends on whether or not the combined energies of the separate particles match a resonance of the potential particle. The resonance levels for each element are related to the NSF. Changes in the NSF lead to changes in the resonance levels that, in turn, lead to changes in the process of fusion. So, it is argued, resonance levels are 'fine-tuned' for the production of certain elements. A 1% increase in the NSF would change the process of fusion in such a way that almost all carbon would burn directly to oxygen, while weakening the NSF by 1% would change the carbon

resonance, precluding the production of carbon from helium and beryllium (Leslie 1989) 35-36.

### *2.2.6 The process of nucleosynthesis*

Two helium nuclei combine to form beryllium (8)<sup>27</sup>, and a further helium nucleus adds to this to form carbon (12).<sup>28</sup> After the helium in the core of the star is burnt, and if the mass of the star is sufficient to produce temperatures of 600 million degrees K in the core (four times more massive than our sun), carbon burning begins. The process continues with the collision of two carbon nuclei.<sup>29</sup> Two carbon nuclei collide and may form magnesium (24), neon (20) with the emission of an alpha particle, or oxygen (16) with the emission of 2 alpha particles. Once all the carbon in the core is burnt and if the mass of the star is large enough to produce temperatures greater than one billion degrees K (nine solar masses), neon burning begins. Neon may combine with an alpha particle to produce magnesium, or neon may eject an alpha particle and become oxygen. If the temperature then exceeds 1.5 billion degrees K, oxygen burning begins. Oxygen burning has several products, including silicon, sulphur phosphorus and magnesium. If the temperature exceeds 3 billion degrees K (stars of 20 solar masses or more), silicon is involved in a large series of recombinations that ultimately end with the creation of iron. The reason stellar nucleosynthesis ends with iron is that the nucleus of iron is as 'energy efficient' (or as tightly packed) as possible. The fusion of smaller elements into larger

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<sup>27</sup> The numbers in brackets refer to atomic mass. This is the total number of nucleons (protons and neutrons) in the nucleus.

<sup>28</sup> Much has been made in the literature over the instability of the element beryllium. Before the discovery of the resonance of carbon (that makes the fusion of beryllium and helium very likely), physicists could not understand how there existed so much carbon in the universe. The existence of the resonance is the subject of the famous anthropic prediction made by Fred Hoyle. The carbon resonance has been called fine-tuned but the emphasis on this is misleading. The whole process of nucleosynthesis is not neat. Considered as a whole the process of the generation of iron from hydrogen is not straightforward at all, and the transition from beryllium to carbon is not significantly different in its nature to any of the other transitions.

<sup>29</sup> The point made in the previous footnote about resonance is illustrated by the fact that oxygen has a resonance just below the combined energy levels of carbon and helium, so carbon and helium do not combine to form oxygen.

elements (up to iron) all release energy. But to build elements larger than iron requires the input of energy.

### *2.2.7 Super novae and the heavy elements*

The creation of elements heavier than iron occurs only in very large stars, stars with a mass twenty five-times that of the sun. Very massive stars still have a great deal of mass surrounding the core when the core has been converted to iron. This mass exerts a great deal of pressure on the iron core. This pressure results in the combination of the protons and electrons of the atoms of iron in the core into neutrons. Thus the core that was made of *atoms* of iron is converted into a core of *neutrons*. A core of neutrons is much more compact than an iron core and so the star implodes. This implosion in turn creates an explosion of great energy (a super nova). And it is in this explosion that elements heavier than iron are created. During this process neutrinos are also released from the core of the star. (Neutrinos are produced when protons and electrons combine to form neutrons.) The energy of the exploding outer regions of the star together with the release of neutrinos from the core combine to blow the outer regions of the star apart. This explosion is the process that distributes heavy elements throughout the cosmos. The value of the NWF is important here, since it affects the way that neutrinos interact with other matter. The neutrinos interact with the expanding matter of the outer regions of the exploding star, and so cause the matter to leave the star and be distributed into the cosmos. If the NWF was weaker the neutrinos would not interact with the expanding matter and thus the expanding matter would not leave the star. If the NWF was stronger then the neutrinos would interact more strongly with matter closer to the centre of the star and their effect would be exhausted before they reached the region of the star that would have otherwise exploded. The value of the NWF is said to be 'fine-tuned' for life, given that life would not be possible if the heavy elements on which life is based remained inside stars.

*2.2.8 And then there was life*

Once a broad range of elements was distributed throughout the cosmos, it was possible for life to evolve. Some of those elements collapsed under gravitational attraction to form planets orbiting suns. The interaction of various forms of energy (e.g., thermal, electrical, and electromagnetic radiation) and various chemical compounds (e.g., water, carbon dioxide, methane and ammonia) on the surface of our planet produced life.

For the evolution of complex life to occur it must have the time in which to do so. We would not be here if the process of evolution were stopped by the death of the sun before we had evolved. So how fast a star burns is important for the possibility of the evolution of complex life. It has been estimated that a star of only slightly more mass than our sun (1.2 solar masses) would burn too quickly for complex life to evolve. The fact that our sun has burnt for the time it has depends on the values of gravity and the EMF. The EMF has an effect on the luminosity of stars. If the EMF were weaker then stars would burn hotter and would burn for less time, and possibly too quickly for complex life to develop. Looking at this another way, if gravity were stronger all stars would be smaller and burn quicker. If gravity were 10 times stronger, then our sun would burn for only 1 million years. Leslie describes research that indicates the ratio of the EMF to gravity is fine tuned to one part in  $10^{40}$  (Leslie 1989) 37.

Our account ends with the production of the basic features of the universe necessary for (carbon-based) life to evolve. I will not consider the evolution of life in detail. This is another complex and not uncontroversial subject. For the purposes of this analysis I assume that, given the fine-tuning of the universe, the existence of life has some possibility of occurring. Thus the fine-tuning of the universe is necessary but not sufficient for the existence of (carbon-based) life.

### 3 Numbers, Theories and Laws

#### 3.1 A counterfactual universe?

Consider the following conditional: *if the laws and initial conditions of the universe were slightly different then carbon-based life would not be possible*. I propose to focus on the antecedent of this conditional: *the laws and initial conditions of the universe were slightly different*. Could the laws and initial conditions have been different? What assumptions underlie the idea that the fine-tuned features could have been different? Further, if they could have been different, how could they have differed? This chapter will assess the assumptions underlying the antecedent of the fine-tuning conditional.

The physics just outlined uses the concepts of four fundamental forces, and four elementary particles. These forces and particles are posited by scientific theory and as with other scientific theories and concepts, those involving the fundamental forces and particles are expressed numerically. Numbers are used in the law of gravity and numbers are used to quantify the mass of protons. Examples of apparently different tuning are illustrated by changing the numbers in laws of nature or scientific theories. I will examine the status of numbers in scientific theories and laws of nature, and the interpretation of these theories and laws. I will argue that the antecedent is only meaningful if we assume a realist interpretation of numbers, scientific theories and laws of nature. Without these assumptions the meaning of the antecedent is called into serious question.

##### 3.1.1 Different tuning?

The fine-tuning debate is based on the assumption that if certain aspects of the universe were slightly different, then carbon-based life would not be possible.

... many have argued that either reality as a whole, or else the spatiotemporal region which we can see, is "fine tuned" to life's needs, by which they mean that tiny changes in its basic properties would have excluded life forms of any plausible kind (Leslie 1990) 2.

... our universe is spectacularly 'fine tuned for Life'. By this I mean *only* that it looks as if small changes in this universe's basic features would have

made life's evolution impossible (Leslie 1989) 2-3.

The fine-tuning debate generally focuses on two ways that the universe could have been different. Firstly, the universe could have had different laws (of the same form as the actual laws but with different constants, or laws of a completely different form). Secondly, the universe could have had different initial conditions.

It should be noted that this division between laws and initial conditions might not be appropriate when considering the origin of the universe. Features of the universe that have traditionally been considered aspects of laws of nature, such as particle masses, can now loosely be considered as initial conditions, set via the Higgs mechanism (Davies 1993) 219. Alternatively, it could be that what we are considering as contingent initial conditions were in fact set by the laws themselves. Hawking maintains that one of the goals of science is to provide a single theory that describes the whole universe, including both the laws and initial conditions (Hawking 1989) 11. However, let me use the traditional division and consider Newton's law of gravitation to see how these slight differences might work in some other possible universe.<sup>30</sup>

Every particle in the Universe attracts every other particle with a force directly proportional to the product of the masses of the particles and inversely proportional to the square of the distance between them. Thus, the force of attraction between two masses  $m_1$  and  $m_2$ , separated by a distance of  $s$ , is given by  $F=Gm_1m_2/s^2$ , where  $G$  is the gravitational constant,  $6.664 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$  (Uvarov, Chapman, and Isaacs 1982) 189.

A slightly different law of gravity might be  $F=Gm_1m_2/s^3$ , which would be weaker than our law. In both these laws, as the distance increases the force diminishes. But if the force of gravity is inversely proportional to the cube of the distance rather than the square, then as the distance increases the force will diminish much faster. Gravity is central to the fine-tuning of the universe. Stars and planets formed because gravity was strong enough to pull matter into clumps during the expansion of the universe. If gravity were weaker, this may not have happened. Another way of changing the law of gravity

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<sup>30</sup> These examples are intended to be illustrative only. They are only loosely based on the physics of fine-tuning.

would be to change the gravitational constant. A slightly different gravitational constant might be  $6.664 \times 10^{-12} \text{ Nm}^2 \text{ kg}^{-2}$ . This constant is 10 times smaller than our gravitational constant. This would make gravity weaker and would result in no stars or planets forming. Finally, a slight difference in initial conditions might be that the total mass of the universe was slightly greater. If so, the gravitational attraction would be greater, and this may have resulted in gravity overcoming the expansion of the universe and the universe collapsing in the first moments of its existence.

Generally, the fine-tuning argument says nothing about what might occur if these values were *substantially* different. The fine-tuning debate, at least as presented by Leslie, is based on the assumption that if the laws and initial conditions were slightly different then (carbon-based) life would not be possible (Leslie 1989) 53. However, if the laws, constants and initial conditions were substantially different, in appropriate ways, then life (carbon-based or indeed some other form) might again be possible. Indeed, Leslie refers to research conducted by Rozental, Novikov and Polnarev that indicates the existence of another life-allowing 'window' when different strength of gravity and electromagnetism are considered (Leslie 1989) 53. Collins also notes the existence of more than one life-allowing 'island' with possible pathways for carbon and oxygen formation (Collins 2003) 185.

However for our present purposes, assume that the fine-tuning means only that if certain laws and initial conditions of the universe were *slightly* different, then life would not be possible. Two questions arise at this point. The first question is: how do we know that (carbon-based) life would not be possible if the fine-tuned values were slightly different? The answer to this question involves the use of mathematical models in physics. Cosmological physicists produce mathematical models that map the evolution of the universe (Davies 1993) 175. These models are basically a series of mathematical equations. Physicists can manipulate the model by changing the mathematical formulae or changing some of the numbers that are associated with the formulae. The fine-tuning debate arose when it was noticed that if certain numbers in the models were changed slightly, then the model developed in a way very differently from the way we understand the universe to have developed. Consider the speed of expansion of the universe in

relation to the gravitational force of attraction. If numerical values slightly different from the 'actual' value for the speed of expansion were used in the model, then stars and planets would not form. This led to the claim that the universe was fine-tuned for life. The second question is: why do we think that the laws could be different? The answer to this question involves assumptions about the place of numbers in scientific theories and laws of nature, and the interpretation of scientific theories and laws of nature themselves. When we consider 'different' laws of nature we do this by changing the numbers in these laws. But what are we really doing? By changing these numbers do we make possible a different universe? I argue that by considering different numbers associated with theories and laws we define an *epistemically possible* universe. But this does not necessarily imply that this epistemically possible universe is ontically possible. Does the fact that we can change the numbers in theories and laws imply that the universes defined by these changes are ontically possible? The answer to this question depends on the interpretation of scientific theories and laws of nature and the way that numbers relate to the world.

### *3.1.2 Epistemic versus ontic possibility*

The fine-tuning debate assumes that the laws and initial conditions of the universe could have been different. So it is assumed that different universes are possible in some sense. This involves questions of modality. Two standard modalities are relevant here: physical possibility and logical possibility. We can discount physical possibility simply because it concerns what is possible *given the laws and initial conditions of the universe* and it is these very features that we are considering to be different. On the other hand, it seems logically possible that the fine-tuned features of the universe could have been different, because it does not seem to be a logical contradiction to suppose (for instance) that the law of gravity could have been different. But the mere fact that we can conceive of a different law of gravity does not mean that the law of gravity 'really' could have been different. I assume real possibilities exist independently from our minds, while conceptual possibilities do not exist independently from our minds. I use the term 'ontic possibility' to refer to 'real' possibility and the term 'epistemic possibility' to refer to 'conceptual' possibility. The important question for the fine-tuning debate is: which

modality is the relevant one? I take it as unproblematic that different fine-tuned values are epistemically possible. However, epistemic possibility does not determine if different universes are ontically possible. If universes with different laws and initial conditions are ontically possible, then the fine-tuning debate is well-founded. But if these different universes are merely epistemically possible, without being ontically possible, the fine-tuning debate is not well-founded.

### *3.1.3 Realism versus antirealism*

A central issue here is the distinction between realism and antirealism. I argue that on a realist interpretation of the physics, the fine-tuning debate is well-founded. However, on an antirealist interpretation of the physics it is not. To explain the distinction between realism and anti-realism I begin with the distinction between observation and theory. For the purpose of this discussion *observation* relates to the aspects of the world to which we have direct observational access, the world of mid-sized objects, the world of trees and kangaroos, trains and kitchens. *Theory* relates to the aspects of the world to which we do not have direct observational access, such as protons and neutrons, electrons and neutrinos. Science links the observational with the theoretical. Science furnishes accounts about how kangaroos relate to neutrinos. The distinction between the realist and the anti-realist positions depends on the status of the theoretical. The realist claims that the theoretical is real in the same sense that the observable is real; the antirealist claims that the theoretical does not have the same ontic status as the observable. The distinction between realism and anti-realism has implications for explanation. For an anti-realist, scientific theories systematise observation and make predictions but theories do not explain observations (Leplin) 394. However, for a realist, theories do explain observations. For a realist, scientific theories are 'true'. If the theories developed by science are true (at least approximately) then there seems to be some sense in which the world is explained. If the theory reflects (at least approximately) the way the world really is, and we understand the theory then we (at least approximately) understand the world. But if the theories are not true, then there is no obvious sense in which the world is explained. If theory does not reflect the way the world is, then theory does not explain the world.

If we embrace realism in relation to the physics outlined in the previous chapter, then we assume that the forces and particles mentioned really exist. For example, Davies believes that the laws of physics “really exist in the world out there” (Davies 2003) 149. Given that they exist, it is meaningful to consider what things would have been like if *these things that exist, had existed differently*. However, if we embrace anti-realism, then we assume that the forces and particles don’t really exist. Given that they don’t really exist, it is misguided to consider what things would have been like if *these things that don’t exist had not existed differently*. We must be clear how the physics of the origin of the universe is interpreted for the fine-tuning debate to be meaningful. The fine-tuning debate is largely located in philosophy but it is based on physics. We must ensure that philosophers and physicists both talk the same language. For it is possible that physicists use one interpretation of the nature of physics and philosophers debating the fine-tuning use a completely different interpretation. Consider the following passage from Hawking.

...you have to be clear about what a scientific theory is. I will take the simple minded view that a theory is just a model of the universe, or a restricted part of it, and a set of rules that relate quantities in the model to observations that we make. It exists only in our minds and does not have any other reality (whatever that might mean) (Hawking 1989) 10.

This interpretation of scientific theory is defended by Christopher Isham. In relation to quantum physics Isham argues that it is best to interpret his own ‘physicalist’ language in a purely symbolic sense that refers to properties of the mathematical model, not what physically exists. In reference to a physical interpretation of the quantum wave function Isham comments, “Unfortunately, I cannot give you a realist (or for that matter, any other physical) interpretation of the mathematical model because this is part of the basic interpretation problem of quantum theory which, as I have emphasized, is still unresolved” (Smith 1997) 167. If we consider a scientific theory as merely existing in our minds and having no other reality, then what are we to make of the antecedent, “the fine-tuned features had been different”? The fine-tuned features can certainly be different in our minds, but this does not imply that the fine-tuned features could ‘really’ have been different.

### 3.1.4 The map is not the territory

I can change the numbers in a theory about the universe and *claim* that this refers to a different ontically possible universe. But this claim may not be justified. Changing numbers in a formula may not imply anything about other ontically possible universes. Consider the distinction between a map and the territory it describes. The territory has certain features and the map has certain features. Some of the features of the territory and the map are, in a certain sense *shared*. There are features of the territory that are represented on the map. There are hills in the territory and (in a certain sense) there are hills on the map. But there are other features of the territory and the map that are not shared. The territory consists of rock, soil, water and so on. The map consists of paper and ink. The map can be folded and put in one's pocket. Consider this 'foldable characteristic' of the map. Just because the map has this characteristic does not mean (ignoring plate tectonics) that the territory can also be folded and put in one's pocket. If we ask the question, is the 'folding characteristic', a characteristic of the map *and* the territory or *just* the map, the answer is clear. Just because the map has a certain characteristic, this does not imply that the territory also has this characteristic.

We can ask a similar question with respect to *theories* of the origin (the epistemic origin) of the universe as distinct from the *real* origin (the ontic origin) of the universe. But when we consider the relation between theories and the world and the relation between laws and the world it is not so easy to see what characteristics are shared and what are not. Theories and laws have certain characteristics that may not be shared by the world. We can change the numbers in the theory because it is such that it allows for the numbers to be changed. In an important sense the theory is *made with* numbers. But this does not necessarily imply reality is such that the universe could have been different. The universe *may not be made with* numbers.

This distinction between the characteristics of the *description* and those of that *described* is closely related to the application of modality and the justification of counterfactuals in the fine-tuning debate. Intuitively there seems to be a meaningful sense in which I can talk about *different* universes. The universe exists and I can conceive of it being different. This seems to justify the assumption that a different universe could exist.

But this intuitive response is not the only one. According to another tradition such 'counterfactual' thinking is based on "relations of ideas or linguistic convention – not by the way the world is, but by the way we conceive or describe it" (Stalnaker 1995) 333. For the fine-tuning debate to be meaningful the possibility of a different universe must be ontic possibility as distinct from mere epistemic possibility. We can *conceive* of the universe being different in a certain way. But this does not imply that, *ontically*, it could have been different in the way we conceive. If modal or counterfactual thinking rests on our *conception* of the world, rather than the way the world is, then this calls into question the basic assumption that it is meaningful to talk as if the universe could have been different. This leads to important issues with respect to scientific theories and the relation between numbers and the world.

### 3.2 Realism, antirealism and numbers

Many examples of the fine-tuning are created by changing numbers in mathematical formulae. Put simply, if a number in a certain formula were to be different and the formula remain true, then life would not be possible. So the status of numbers is central to the fine-tuning debate. But does our ability to change a number in a mathematical formula imply that the world could have been different? The answer depends on how numbers relate to the world, or put another way, whether we are realist or antirealist about numbers. This is a crucial question in both the philosophy of mathematics and the philosophy of science.<sup>31</sup> We will not come to a definitive answer here, but we can review what is relevant to the fine-tuning debate. One way to consider the question of how numbers relate to the world is to use the distinction between the characteristics of the *description* and the characteristics of that *described*.<sup>32</sup> So are numbers a characteristic of

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<sup>31</sup> For examples of this debate see (Field 1980) (Mortensen 1998).

<sup>32</sup> This distinction, between the characteristics of the description versus the characteristics of that described, is related to an important question in the philosophy of mathematics, namely, whether mathematics merely *represents* the world or whether it actually *describes* the world? (Brown 2000) 262 However, we must be careful about terminology here because the term 'description' is being used differently in each case. When considering the two contrastive-pairs of 'representation' versus 'description' and the characteristics of 'the description' versus 'that described', the features of the 'representation' corresponds to the 'characteristics of the description', while the features of the

what is *described* or merely a characteristic of the *description*? In other words, are numbers characteristics only of the map or also of the territory? Numbers are clearly a characteristic of models of the world but are they also a characteristic of the world itself? Are numbers *epistemic* or *ontic*? It is possible that the numbers are a feature of the models of nature, but not of nature itself. Now the fact that numbers exist in the models of the universe makes it possible to conceive of models that have different numbers. But if numbers are characteristics only of the model and not the world, then these different universes have no ontic referent and the fine-tuning debate is undermined.

### *3.2.1 How does mathematics hook onto the world?*

There is another way to consider the question of mathematics relation to the world. James Robert Brown asks: 'How does mathematics hook onto the world?' He identifies this as the central concern of *measurement theory* (Brown 2000) 257. Numbers may hook onto *objects* or *properties of objects*. Brown characterises the idea that numbers hook onto *objects* as associated with the empiricist tradition, the natural language of this approach being first order logic. He characterises the idea that numbers hook onto *properties of objects* as 'somewhat Platonistic', and the natural language of this approach being second order logic (Brown 2000) 259. He illustrates these two approaches by considering weight.

To say that the weight of a and b combined is such and such, is to say, according to the first order theory of measurement, that there is an object c which equals the weight of a and b combined (understood in a somewhat operationalist way, with c balancing a and b on a scale). This is physically unrealistic, and at best an idealization. However, it is not a problem for the second order theory, since it is not objects, but the properties that are assigned numbers. The property *weight* is postulated to be continuous and unbounded; there need not be exemplars of any particular weight in order to talk meaningfully about it.

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'description' corresponds to the 'characteristics of that described'. So if mathematics only *represents* the world then features of mathematics are only characteristics of the *description*. But if mathematics *describes* the world then some of the features of mathematics are characteristics of the *world*.

These two accounts of measurement tie into rival accounts of laws of nature. The relations that hold in the (nonmathematical) relational structure are presumably laws of nature. The empiricist-motivated regularity theory fits harmoniously with the first order theory. The more realist account of some philosophers which takes a law of nature to be a relation between universals (i.e., properties) fits very naturally with the second order version. So the question, Does mathematics hook onto objects or onto properties of objects?, may have a bearing on the metaphysical issue of the nature of scientific laws (Brown 2000) 259.

If numbers hook onto the properties of objects then the fine-tuning debate is well-founded. The debate requires the possible existence of different universes. We need to be able to 'talk meaningfully' about these different universes and the 'properties of objects' approach allows us to do that (just is it allows us to talk meaningfully about counterfactual weights). However, if numbers hook onto objects, then the fine-tuning debate is called into question. Following Brown, the implication of numbers hooking onto objects rather than the properties of objects is that there *do* need to be exemplars of these objects in order to talk meaningfully about them. But the implication is the same for different universes. There needs to be exemplars of different universes to talk meaningfully about them. But this begs the question. If numbers hook onto objects rather than the properties of objects, then it may not be meaningful to talk about 'different universes'.

This comes back to the distinction between the characteristics of the *description* versus the characteristics of that *described*. If the numbers hook onto the objects, then the numbers are a characteristic of that described. If the numbers hook onto the properties of the object, then the numbers are characteristic of the description. This point can be illustrated by the question whether aspects of the world are infinitely divisible and unbounded. Consider the possibility that mathematics is a characteristic of the description of the world but not the world itself. The real numbers are continuous and unbounded. So the real numbers, used as a measuring tool, could measure the world if the world were also continuous and unbounded. But it may not be so. However, if the real numbers were characteristics of the world itself, then presumably aspects of the world would actually be continuous and unbounded. The assumptions about the way numbers relate to the world significantly affects our perspective on the nature of the

world. Mathematics plays a central role in theory construction, but 'it is sometimes difficult to distinguish the mathematics proper from its physical counterparts' (Brown 2000) 259. In this situation we must defend ourselves against error. One possible error concerns the existence of mathematical artifacts.

### *3.2.2 Different universes as mathematical artifacts*

Brown gives the example of the 'average family' with 2.5 children as a mathematical artifact. This family is generated by the mathematical procedure of averaging but it has no counterpart in the world. We do not expect to find such a family in the world and importantly, we do not expect to find other possible universes in which there are families with 2.5 children. The 'different universes' on which the fine-tuning debate is founded may also simply be 'mathematical artifacts'. The default assumption in the fine-tuning debate is that the fine-tuned constants can vary continuously (Manson 2000) 342. This idea echoes the statement made by Brown above, "The property *weight* is postulated to be continuous and unbounded; there need not be exemplars of any particular weight in order to talk meaningfully about it." However, this meaningfulness is based on a realist position. But notice that if we adopt an antirealist position, then we must be careful that the continuous and unbounded nature of numbers does not tempt us to refer to the space of possible universes as continuous and unbounded without appropriate justification.

The concept of fine-tuning depends on the notion that if the values were changed 'slightly' then life would not be possible. Of course the variation of the values is epistemically possible. But are slightly different values ontically possible? Perhaps the idea that the fine-tuning can vary 'slightly' is a mathematical artifact? On a realist interpretation of numbers, it is meaningful to talk about the fine-tuning without exemplars of 'slightly different' universes' just as "there need not be exemplars of any particular weight in order to talk meaningfully about it." But on an antirealist interpretation of numbers the meaningfulness of the notion of fine-tuning is called into question. Consider the possibility that the finely-tuned values cannot vary continuously but only discretely (that is if they can vary at all). If they can vary, but only discretely, the notion of fine-tuning as opposed to what Robert Clifton has called 'course-tuning' is called into question (Clifton 1991). Perhaps these 'slightly different universes' are

only artifacts in the same sense that the average family is an artifact. If so, then the fine-tuning debate is undermined. If the 'different universes' are in fact only artifacts, then the surprise that some people feel at the fine-tuning is equivalent to being surprised at the fact that the world does not contain any families with 2.5 children.

### **3.3 Scientific theories: statements or models?**

Another way to examine the assumptions underlying the fine-tuning debate is to consider the nature of scientific theory. Here I consider two approaches to theory, one that takes *statements* as fundamental, and the other that takes *models* as fundamental (Giere 2000) 523. Each of these approaches is considered with respect to realism and antirealism.

Consider the view that theories are (collections of) statements. In this approach, laws of nature are universal statements of a certain kind. If we assume realism, then the statements are 'truth-apt'. If the statements are true, then the fine-tuning debate seems well-founded. If the statements refer to laws, then the laws are real, and there is a meaningful sense in which we can ask, why are the laws this way, as opposed to some other way? However, if we assume anti-realism, then the statements are not true, and the fine-tuning debate is undermined. If the statements do not refer to anything in the world, then there is no meaningful sense in which we can ask: why is the world this way?

However, there are good reasons to doubt the statement-based approach to scientific theories. Ronald Giere argues that there seem to be few, if any universal statements (laws) that are true; thus he favours a model-based interpretation of scientific theory. "What have traditionally been interpreted as laws of nature thus turn out to be merely statements describing the behaviour of theoretical models" (Giere 2000) 523.<sup>33</sup>

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<sup>33</sup> Giere further argues that what have been taken as universal generalizations should be interpreted as parts of definitions (Giere 2000) 523. This idea that laws should be interpreted as definitions will be explored later in this chapter in the context of Aristotle and Wittgenstein.

Consider the model-based view of scientific theories. Following Carl Craver, I take this to be the claim that, theories specify or define abstract or idealized systems. Models are the representational or abstract structures that satisfy (or instantiate) these specifications or definitions and the abstract and idealized system is itself a model of the theory (Craver 2002). Again, consider this issue in the context of realism and anti-realism. The realist position is that the real world is (at least approximately) one of the models of a good theory (Hesse 2000) 302. If the real world is (at least approximately) one of the models of a theory, then it seems reasonable to ask why the world is *this* model as opposed to some other model. However, the antirealist position does not assume that the real world is (even approximately) one of the models of a good theory. On the antirealist position, models do not hold truth-values in relation to the world in any significant sense (Hesse 2000). On an antirealist interpretation of models the fine-tuning debate is undermined. We can change the numbers in the models of the universe but this does not imply that the universe could have been different in the way the model could have been different.

To understand this, consider what are called 'unintended models' (Suppe 2000) 10. The mathematical nature of many models allows for different numbers to be used, and these can be considered as 'unintended models'. But what is the status of these other models? On an antirealist interpretation these unintended models are considered "merely artifacts of the form of representation" (Giere 2000) 521.

Consider creating a model of the universe. Clearly the universe is the intended system. But now consider changing the numbers in this model. We can change the numbers in the model. But these 'different universes' should be considered unintended models. If these different universes are considered artifacts of the form of representation then they carry no argumentative weight and the fine-tuning debate is undermined.<sup>34</sup> The

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<sup>34</sup> Consider also the distinction between syntactic and semantic interpretations of scientific theory. Frederick Suppe has noted many philosophical controversies based on syntactical analyses where unintended models are offered as counter examples. He goes on to argue that these counterexamples are artifacts of the syntactical approach to formal analysis. The semantic approach pre-empts these artifacts by focusing only on the intended system (Suppe 2000) 10. On the semantic approach to theory, theories are not considered true or false *simpliciter*, but are true of some systems and not true of others (Salmon et al.

implications of the model based approach to scientific theory has been noted by Barry Smith.

The role of ontology therefore came to be usurped by the construction of set-theoretic models, and for the world itself there came to be substituted mathematical artefacts having convenient algebraic properties but otherwise bearing little or no relation to the flesh-and-blood subject matters of scientific theories (Smith 2000) 374.

Taking theories as set-theoretic models has important implications for the fine-tuning debate. Statements made by physicists about the fine-tuning may concern models, not the real world. Given Hawking's position on scientific theories, perhaps his talk of fine-tuning refers only to the models of the universe and not the universe itself. It is not mysterious that numbers in models can be changed. But this does not necessarily imply anything about different ontically possible universes.

### 3.4 What is the nature of laws of nature?

Consider laws of nature with respect to the distinction I employed throughout this chapter between the characteristics of the description and the characteristics of that described. Recall the importance of distinguishing the map from the territory. Just because I can fold the map and put it in my pocket does not imply that I can fold the territory and put it in my pocket. This relates to a central question concerning laws of nature. Are laws of nature ontic or epistemic? Are laws of nature characteristics only of the map or also of the territory?<sup>35</sup> The answer to this question impacts on the status of the 'different' universes that underpin the fine-tuning debate. If laws of nature are *ontic*

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1992) 121. If we consider the universe to be the intended system, then our theory may be true of this universe, but there is no reason that the theory will be true of any other universe. The 'slightly different' universes that do not allow for life, *that are the basis of the fine-tuning debate*, can be considered as other systems. There is no reason to suppose that the theory will be true of these other systems. If so, then we simply cannot say that these 'slightly different' universes do not allow for life. This is because the theory that determines that these other universes do not allow for life does not apply to these other universes. A similar point has been made by (Fulmer 2001), although it was not made in the context of the semantic interpretation of theory.

<sup>35</sup> Historically the expression 'laws of nature' has been used to refer to both (certain) regularities in nature and to the statements that describe those regularities (Harré 2000) 213. This distinction is similar to the ontic/epistemic distinction I am considering here.

(characteristics of that described), then we have warrant to consider ‘different’ universes. We can reasonably consider why these *ontic* laws are the way they are as opposed to some other way, because they have an independent existence. But if laws of nature are *epistemic* (characteristics only of the description), then that warrant is called into question. It is no longer reasonable to consider why these *epistemic* laws are the way they are opposed to some other way, because they do not have an independent existence.<sup>36</sup> This issue is central to a counterfactual analysis of laws of nature. Could the laws of nature have been different?<sup>37</sup> If laws are *ontic* (of the world), then the application of counterfactual analysis to consider ‘different’ laws of nature seems warranted. But if laws are *epistemic* (conceptual), then the counterfactual laws are simply epistemic structures with no ontic referent.

There are various approaches to the interpretation of laws of nature. Laws can be broadly considered as Humean and non-Humean. Humean accounts ground laws in theorizing minds, while non-Humean accounts ground laws in reality independent of our minds (Loewer 1995). A recent example of a Humean approach is that advocated by David Lewis (Lewis 1973), while a recent example of a non-Humean approach is that advocated by David Armstrong (Armstrong 1989). While the Humean/non-Humean division is common, it will be useful to follow an alternate division used by (Harré 2000). Rom Harré identifies three interpretations that have been dominant in the history of the analysis of laws of nature. These are: laws as *descriptions of natural tendencies*, laws as *summaries of experience*, and laws as *relations among concepts*.

When taken as descriptions of natural tendencies, laws can be considered as referring to the “powers, dispositions or tendencies of natural systems to bring about observable

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<sup>36</sup> Strictly speaking, it may be reasonable to consider why these epistemic laws are the way they are, but this relates only to epistemology and not ontology.

<sup>37</sup> Here I should be careful to distinguish the role of counterfactuals in laws from the application of counterfactual analysis to laws themselves. Laws, it is traditionally assumed, support counterfactuals. But this support of counterfactuals is in the structure of laws. There is no (necessary) justification of the assumption that different laws are somehow possible just because laws themselves are said to support counterfactuals.

phenomena” (Harré 2000) 218. As such, laws can be considered *ontic* – of the world, or as characteristics of that described.<sup>38</sup> This interpretation supports the counterfactual analysis of ‘different laws’ that is fundamental to the fine-tuning debate. If laws are considered as descriptions of natural tendencies the fine-tuning debate is well-founded. Alternatively, if laws are considered as mere summaries of experience they can be considered as products of our theorizing minds (Loewer 1995) 268. As such, they can be considered *epistemic* – or as characteristics of the description.<sup>39</sup> This interpretation does not support the counterfactual analysis of ‘different laws’ essential to the fine-tuning debate. If laws are considered as summaries of experience the fine-tuning debate is not well-founded.

Now focus on the interpretation of laws of nature as ‘relations among concepts’.<sup>40</sup> Here I examine Ludwig Wittgenstein (Wittgenstein 1953) and Aristotle (Aristotle 1975). The fine-tuning debate assumes that the laws of nature could have been different. If laws of nature are relations among concepts, then the idea that there could have been different laws may be meaningless. Consider Wittgenstein’s idea of *frame propositions*. In envisaging laws of nature as relations among concepts, Harré suggests that laws function to set the boundaries of discourse. As such, the laws have a notable property. The laws are not true or false. A statement negating the laws is not false but meaningless. Thus “it is not false to say that the force applied is not equal to the product of the mass and acceleration, but meaningless, if the Newtonian second law is being used to specify the way the concepts of ‘force’, ‘mass’ and ‘acceleration’ are being used” (Harré 2000) 216. Applying Wittgenstein’s idea to the universe as a whole, ‘different laws’ is equivalent to the negation of ‘these laws’ (different laws =  $\neg$  these laws). If the laws of nature are interpreted as frame propositions, then to say that the universe could have had different

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<sup>38</sup> This interpretation can be considered as broadly non-Humean.

<sup>39</sup> This interpretation can be considered as broadly Humean.

<sup>40</sup> The positions of Wittgenstein and Aristotle in this section are taken from (Harré 2000).

laws is neither true nor false but meaningless. So to say that the laws of the universe are fine-tuned, implying that they could have been different, is meaningless.<sup>41</sup>

For Aristotle laws of nature are grounded in 'essences'. Harré characterises an essence as the definition of a kind or how "properties relate to one another" in kinds. He notes that for Aristotle these "property relations are given or immediate, and stand in no need of further accounting" (Harré 2000) 215. This is similar to Wittgenstein's 'framing propositions'. If, when we talk about the fine-tuning we are talking about the fundamental nature of the universe, then both Aristotle and Wittgenstein would signal caution. Aristotle might say that the universe's property relations are 'given or immediate and stand in no need of further explanation'.

Aristotle's position in *Posterior Analytics* is that there can be "no scientific knowledge of individuals, only types, species and sorts" (Harré 2000) 215. We only have knowledge of an individual as a member of a kind. If we take Aristotle at his word, and make the additional assumption that there is only one universe, then it seems that we can have no scientific knowledge of the universe *as a whole*. Obviously we can have scientific knowledge of species, types and sorts *in the universe*, but we cannot have scientific knowledge *of the universe as a whole*, simply because there is only one. This point concerns the notion that the universe is unique. Throughout this thesis the uniqueness (or otherwise) of the universe will be centrally important.<sup>42</sup> Perhaps if the universe is unique, then it does not need further explanation. Alternatively, if it does need further explanation, then perhaps Aristotle would argue that science cannot provide that explanation.<sup>43</sup>

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<sup>41</sup> This point is made in relation to the fine-tuning of laws; it does not necessarily relate to any possible fine-tuning of initial conditions.

<sup>42</sup> As we will see later in the thesis, science may provide an explanation of this universe as being a quantum fluctuation of a larger 'vacuum'. But then this universe has become a member of the kind 'universe'. The task then would be to explain the quantum vacuum.

<sup>43</sup> That science cannot provide an explanation for the universe as a whole is implied by the Aristotelian account of possibility. Alexander Pruss notes that it is unclear how an Aristotelian could account for the laws of nature being different (Pruss 2002) 330.

### **3.5 The need for ontic possibility**

The fine-tuning debate is founded on the consideration of possible universes that are different from our universe. Obviously we do not create different universes simply by conceiving of them. We must ensure that these other conceivable universes are ontically possible. If this is not so, then the fine-tuning debate has no justifiable foundation. These 'different' universes are defined in the structure of scientific theories using laws of nature and numbers. But scientific theories, laws of nature and numbers may not correspond to reality. This precipitates the distinction between the characteristics of the *description* and the characteristics of that *described*. If it is only the structure of the description and not the structure of that described that generates counterfactual universes, then the fine-tuning debate has no foundation. In other words, if scientific theories, laws of nature and numbers are *ontic* – of the world, then the fine-tuning debate is well-founded. But if they are merely *epistemic* – descriptions of the world, then the debate is not necessarily well founded. This division between *the epistemic* and *the ontic* can be considered as equivalent to the division between antirealism and realism with respect to numbers, theories and laws of nature.

So the meaningfulness of talk of 'different' universes is conditional on particular interpretations of scientific theories, laws of nature and the way numbers relate to the world. If these interpretations are not accepted then the fine-tuning debate is undermined. Alternatively, if protagonists and antagonists in the debate use different interpretations without making them explicit, then the debate will be confounded.

## 4 The Possibility Space of Universes

### 4.1 Are other universes possible?

Much of the fine-tuning debate concerns the concept of *probability*. However an event cannot have a probability (other than zero) unless it is first possible. So it is appropriate that possibility be considered before probability. Many of the issues that I consider in this chapter with respect to *possibility* are implicit in the debates concerning the *probability* of the fine-tuning. These issues resurface when I consider probability and this will be somewhat repetitive. But nonetheless it is useful to consider these issues here with explicit reference to possibility before I consider them with respect to probability.

I seek to determine which other universes are possible. I rely on the distinction between ontic possibility, epistemic possibility and logical possibility. I take ontic possibility to be that which is 'really' possible. The ontically possible is that which 'really' could have existed. I take this to be distinct from logical possibility. I take logical possibility to be all that is not self-contradictory. But I claim that all that is logically possible may not be ontically possible. I take epistemic possibility to be all that is conceivably possible. I assume that the logically possible and the epistemically possible are not necessarily co-extensive. By this I mean that there may be logically possible events that are not conceivable and there may be conceivable events that are not logically possible. Further, the distinction between epistemic and ontic possibility highlights the fact that I may think that something is possible (epistemic possibility) when in fact it is not 'really' possible (ontic possibility).

Seemingly, the fine-tuned form of this universe is contingent. But the form of the universe might be ontically necessary.<sup>44</sup> This seems to be what Hawking implies when he suggests that we may discover a complete unified theory that predicts all the finely-tuned features of the universe (Hawking 1989) 132. If the form of this universe is ontically necessary, then much of the following discussion concerning other possible

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<sup>44</sup> The form of the universe may be necessary, without the existence of the universe being necessary.

universes is redundant. However, as yet there is no good reason to believe that the form of the universe is ontically necessary and for the purposes of this thesis I assume that the fine-tuned form of the universe is ontically contingent.

Let me highlight the distinction between *some* universe and *this* universe. It may have been ontically necessary that a universe of some sort or other exist. But we do not need to address this issue. However the distinction between some universe and this universe is relevant to the notions of necessity and contingency. The way we define an event affects whether we consider it necessary or contingent. Consider these three definitions of outcomes of a coin toss: *outcome one* 'heads', *outcome two* 'tails' and *outcome three* 'heads or tails'. Outcomes one and two are contingent (they may not happen) but outcome three is necessary. The coin must land 'heads or tails' (ignore the possibilities that the coin lands on its edge, or does not land at all). In a situation where there will certainly be an outcome, *some* outcome will be necessary, while any *particular* outcome may be contingent. Note that how the outcomes are defined affects the necessity or contingency of those outcomes.

#### **4.2 Various possibility spaces**

There are two obvious possibility spaces: physical and logical. We cannot use physical possibility space to discuss the fine-tuning of the universe. Logical possibility space is all that is not self-contradictory. Although possibility space is not a concept that is widely used in the current fine-tuning literature, it seems that logical possibility underpins the notion of logical probability that is used in the debate (Leslie 1989) 138, (Swinburne 2004) 172. However, I contend that logical possibility space *simpliciter* will not help us understand the fine-tuning. To 'explain' the fine-tuning by pointing out that it is one of the logical possibilities does little to give explanatory satisfaction. I see the task of explaining the fine-tuning as a task of *excluding* some of the logical possibility space. So what is required is a possibility space more inclusive than the physical, but less inclusive than the logical. Here I must guard against simply creating a possibility space arbitrarily. I must have good reason to choose it. In developing a workable possibility space I use an epistemically conservative approach. I build on what we know about the physical world. Thus I do not make unsupportable metaphysical claims but

rather use what we know of physical possibility to develop a concept that I call ontic possibility.

#### *4.2.1 Physical possibility*

Put simply, physical possibility is what is possible given the laws of physics and the initial conditions of the universe. Now we must make a distinction between physical necessity and physical possibility. This is related to the distinction between physical determinism and indeterminism. If physics were completely deterministic then, given the laws and initial conditions there would be no physical possibilities beyond what actually occurs; all that occurred would occur necessarily. But for the purposes of this discussion assume that there is some physical contingency in the world. Quantum mechanics embraces indeterminism (Healey 2001). This allows for some contingency. But contingency in the world may be more widespread than quantum indeterminacy. Let me assume the existence of physical contingency other than quantum indeterminacy. Examples of physical contingency are the height of a particular human or the average mass of a species of mammal. These can be different, within certain limits. For example different nutrition levels affects the growth of humans. Thus different levels of nutrition would result in a specific human growing to a different height. More generally evolution can affect the average mass of certain species of mammal. Obviously there will be a range of masses among individuals of that species. But the species as a whole has an average mass. Over a long time period environmental effects influence that mass. These differences would not contradict the scientific laws, so these differences would be physically possible. But note that some things are not physically possible. Take the mass of a land mammal. This is limited by the ability of that mammal to support its own weight. There is a mass greater than which land mammals cannot support themselves. If the gravitational attraction between mammals and earth were less then land mammals could have greater mass.<sup>45</sup> Here the laws of physics dictate what is physically possible.

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<sup>45</sup> There may be an unforeseen physiological reason that I have overlooked here, but all things being equal, I think this illustration is appropriate. Notice that marine mammals can exceed this average mass due to the environment in which they live.

Excluding the issue of determinism and indeterminism, the laws of physics allow for some physical contingency, but the laws of physics also limit physical possibility.

#### *4.2.2 Logical possibility*

The logically possible is all that is not logically contradictory. "A and not A" is a contradiction and thus logically impossible, but all else is logically possible. The realm of logical possibility has prompted much of the fine-tuning debate. It seems logically possible that the laws of physics could be different. Consider Newton's law of gravitation and for the purposes of this discussion take this law to be true. Every particle in the universe attracts every other particle with a force directly proportional to the product of the masses of the particles and inversely proportional to the square of the distance between them. Thus, the force of attraction between two masses  $m_1$  and  $m_2$ , separated by a distance of  $s$ , is given by  $F=Gm_1m_2/s^2$ , where  $G$  is the gravitational constant,  $6.664 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$  (Uvarov, Chapman, and Isaacs 1982) 189. There are many apparently logically possible ways that this law could be different. For example: take  $s^2$  and change it to  $s^3$ , or change any of the numbers that appear in the gravitational constant (change 6.664 to 51.449), or take  $\text{kg}^{-2}$  and change it to  $\text{kg}^{-14}$ . Not only does it seem logically possible to change the numbers in the law, but it is also logically possible to change the law itself. Logically, gravitation could have the following form:  $F=Gs^2/\sqrt{(m_1m_2)}$ . But even these are only simple changes. Consider gravitation based on something completely different - perhaps gravitational attraction could be proportional to the velocity of the particles interacting, or gravity not exist at all. These options all seem logically possible. All that logical possibility space excludes is that which is self-contradictory. I contend that, as such, logical possibility space is unhelpful. The lack of contradiction does not convince me that a certain state of affairs is *really* possible. This makes it unlikely that logical possibility space can help explain the fine-tuning. In order to gain understanding we need to exclude some of the logical space.

#### *4.2.3 Ontic possibility and epistemically responsible speculation*

Physical possibility is too narrow and logical possibility is unhelpful. I need some other modality. The term *ontic possibility* provides a label for what I will now discuss. As the

name implies, the ontic possibility space defines what is ontically possible, or, in other words, what is *really* possible. It is difficult to be definitive regarding the nature of ontic possibility. Perhaps ontic possibility is co-extensive with logical possibility.<sup>46</sup> If so, then the introduction of ontic possibility space has not helped because it is no different from logical possibility space. The specific nature of ontic possibility space is not our central concern here, but for the purposes of this discussion let us assume that it is a possibility space located somewhere 'between' physical possibility and logical possibility.<sup>47</sup> The physically possible is also ontically possible but there may be logical possibilities that are not ontically possible. The concept of ontic possibility will be useful in coming to understand the nature of the possibility motivating the fine-tuning debate.

The laws of physics can be characterised as forming a hierarchy. Some can be characterised as more fundamental than others. Many aspects of physics that appear to be fine-tuned are associated with the fundamental laws of physics. But history shows that fundamental physical laws are revised and new 'deeper' laws take their place. We do not know the nature of these 'deeper' laws yet, or even if they exist. We may have reached the bedrock of reality, but let me assume that we have not. Although we do not know the nature of these 'deeper' laws, we can speculate about their structure. This is the realm of ontic possibility. The detail of this speculation occurs in the next chapter but now I offer some introductory comments on the form that this speculation will take. This will be disciplined and reasonable speculation. It is grounded in phenomena that we have good reason to believe actually exist in the physical world, for example, quantum systems and non-linear (chaotic) systems. That these systems are thought to occur in the physical world is justification for considering the possibility that they occur at an ontic level. The characteristics of such phenomena in this world will be used to extrapolate into the ontic realm.

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<sup>46</sup> Some writers have used the term 'metaphysical possibility' in a sense that suggests they take metaphysical and logical possibility to be co-extensive (Pruss 2002) 317. But others consider metaphysical possibility to be narrower than logical possibility (Loux 1979) 27.

<sup>47</sup> Another option is that the ontic possibility space includes possibilities that are logically impossible. Such a situation might help resolve some of the paradoxes of modern physics. See (Lycan 2002).

### **4.3 The nature of possibility space**

#### *4.3.1 Conceptualising possibility space*

Possibility space contains all the possibilities in a specified modality. So physical possibility space contains all physical possibilities. Logical possibility space contains all logical possibilities. Ontic possibility space contains all ontic possibilities. There are several ways to conceive of possibility space. One way is to consider all the distinct possibilities as members of a set. For example, one way of specifying the possible outcomes of a roll of a die is the set {1, 2, 3, 4, 5, 6}. This conceptualisation is appropriate for simple situations. But for more complex situations (as in the fine-tuning) we need something more. For complex situations, we can conceive of the possibility spaces as n-dimensional spaces, where each distinct point in the space (identified by its co-ordinates) represents a distinct possibility. There are different ways that we can represent the possibilities in this space. A point in the space could simply be arbitrarily assigned a corresponding possibility or alternately the points in the space could be assigned in a more coordinated fashion.<sup>48</sup> For example, when considering the possibility space of universes, one dimension of this space might represent the speed of light. Universes with different speeds of light would have different values on this dimension. Universes other than our own with the same speed of light would have the same value on this dimension as our own universe. Universes that did not have light, and thus no speed of light, would have a value of zero for this dimension. Similarly our universe will have a value of zero for all dimensions in the possibility space that represent features of universes that our universe lacks. This conceptualisation of possibility space has limitations. It works well for features that have a numerical value (the speed of light say) but it is less clear how to represent difference in the structure of a law (the law of gravity say) with this representational schema. However, these concerns aside, this n-dimensional space is a useful aid to understanding. The central idea is

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<sup>48</sup> I have developed this concept of a n-dimensional space based on the 'probability phase space' used by Phil Dowe in the manuscript "The Inverse Gambler's Fallacy Revisited: Multiple Universe Explanations of Fine Tuning" (Dowe)

simply that the possibility space represents each possibility as a distinct point in the space. I will use points in the possibility space to individuate different possible sets of laws and initial conditions.<sup>49</sup> This approach also introduces a metric of closeness.

#### *4.3.2 Is possibility space discontinuous or continuous?*

Now we have a conceptualisation of possibility space let us examine its structure. Is the space discontinuous or continuous? A continuous space has no 'gaps' while a discontinuous space has 'gaps'. In other words, in a continuous space, any real number on any dimension in that space would correspond to a possibility in that space, while in a discontinuous space, any real number on any dimension in that space may not necessarily correspond to a possibility in that space. I maintain that logical possibility space is largely continuous. It seems logically possible that the speed of light could hold a value equivalent to any positive real number. So every point along the 'speed of light' dimension represents a distinct logically possible universe. Thus I assume logical possibility space is largely continuous on every dimension in the space.<sup>50</sup> However there may be regions of logical impossibility. For example, if a set of co-ordinates represented a logically impossible universe, then that point would not be part of the logical possibility space.

Physical possibility space is clearly continuous in some senses and discontinuous in others. Wavelengths of light can vary continuously in the visible electromagnetic spectrum. So it is physically possible for light to have any wavelength in the visible spectrum. On the other hand, the chemical elements vary discontinuously. It is physically possible for an atom to contain 1 or 2 protons but not for an atom to contain 1.5 protons.

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<sup>49</sup> Note that a point in the possibility space (if it represents a universe that incorporates indeterminism) may represent more than one possible world.

<sup>50</sup> There are problems here when I consider the *continuity* between laws structured differently, and laws with the same structure, but simply with different numerical values. When I consider differences only in the numerical values it does not seem problematic to consider this in a continuous space. However it is not clear how laws structured differently could be considered continuous. Thus there may be 'gaps' in the possibility space between laws that are structured differently.

While I maintain that logical possibility space is (largely) continuous and physical possibility space is in some senses continuous and in other senses discontinuous, the discontinuity or continuity of ontic space is an open question. It may be continuous or it may be discontinuous. To illustrate this, consider a wall made of concrete or brick. A concrete wall can be any height, so it can vary continuously, while the height of a brick wall must vary discontinuously, as multiples of bricks.<sup>51</sup> If ontic space is continuous it is analogous to the concrete wall, if the ontic space is discontinuous it is analogous to the brick wall.

#### *4.3.3 Discontinuous possibility space: measurement and mathematical artifacts*

In the case of discontinuous possibility space there is the risk of mathematical artifacts. Consider the concrete or brick wall. If we did not know the structure of the wall we may look at the height of this wall and ask why it was not slightly lower. Indeed, without knowing the structure of the wall, this would be a perfectly reasonable question. Or perhaps we are not content just looking at the wall and wondering, so we measure the height of the wall. If we use the real number line to measure the height of the wall and we do not use it with care, we leave ourselves vulnerable to the illusion of mathematical artifacts. If we know the wall is made of bricks, then we can measure it using bricks and discover that it is five bricks high and this is safe enough. But if we don't know the wall is made of bricks and we measure it some other way, say with a ruler, we will discover that it is, say, 15 inches high. Then we might assume, naturally enough, but nonetheless *erroneously*, that the wall *could have been* 14 inches high. Indeed, we could spend some time wondering why it is not 14 inches high, which it could never be while made of bricks that are 3 inches high. In this situation a 14 inch high wall is a mathematical artifact. If the wall is made of nothing but bricks that are 3 inches high, a 14-inch high wall is impossible.

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<sup>51</sup> This is an idealization. Concrete is made of atoms of discrete size and bricks can vary in size.

#### *4.3.4 Partitioning possibility space: demonstrative and non-demonstrative partitions*

Possibility space consists of all possibilities. We can consider all the distinct possibilities individually or we can consider the possibilities in classes. This consideration of possibilities as either individuals or classes relates to how the space is *partitioned*. For our purposes we examine two possible partitions. The first places every distinct possibility in a separate partition; call this a *non-demonstrative* partition.<sup>52</sup> The second places each distinct possibility in one of two classes; call this a *demonstrative* partition.<sup>53</sup> To understand this distinction, consider the outcomes of a roll of a die. A non-demonstrative partition will be of the form  $\{1, 2, 3, 4, 5, 6\}$  and the demonstrative partition will be of the form (say)  $\{3, \neg 3\}$ . The general form of the non-demonstrative partition is  $\{A, B, C, \dots\}$  and of the demonstrative partition is  $\{A, \neg A\}$ .

#### *4.3.5 Non-demonstrative & demonstrative as objective & subjective partitions*

The fundamental distinction I am considering is between demonstrative and non-demonstrative partitions. However there is a relation between demonstrative partitions and subjectivity, and non-demonstrative partitions and objectivity that is important to examine. The relation is not completely unproblematic but the general point is that objective differences underlie non-demonstrative partition while subjective differences underlie demonstrative partitions. Furthermore, I contend that in the practical process of partitioning possibility space, non-demonstrative partition should be the *default* partition. This is due to its relationship with objectivity. Demonstrative partitions, as I will argue, are fundamentally related to 'interest', while non-demonstrative partitions can be characterised (rather loosely) as 'disinterested' partitions. I will argue that in

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<sup>52</sup> Placing every distinct possibility in a separate partition works well for a finite discontinuous possibility space because there are a finite number of partitions. However, in an infinite discontinuous, or a finite continuous, or an infinite continuous space there will be an infinite number of partitions. This is difficult to manage. In order to minimise this management challenge I can partition using regions of the space rather than individual points in the space. However this only 'minimises' the problem. For example, if the possibility space is infinite, there are still an infinite number of finite regions in an infinite space.

<sup>53</sup> The terms *demonstrative* and *non-demonstrative* are based on the grammatical 'demonstrative determiners' *this, that, these, those* (Hardie 1990) 146.

order to replace the (default) non-demonstrative partition with a demonstrative partition, the objectivity of the demonstrative partition would need to be demonstrated. This, I will argue, is not easy.

First consider the relation between non-demonstrative partitions and objectivity. Take the non-demonstrative partition of the possibility space of the roll of a die,  $\{1, 2, 3, 4, 5, 6\}$ .<sup>54</sup> There seems to be a natural sense in which this partition is objective in that it is not distinguishing any particular 'this' from '¬this'. I consider that the objectivity of this partition is straightforward and uncontroversial. However my claim that a demonstrative partition is subjective is more controversial.

Take the demonstrative partition and consider whether it is subjective or objective. Consider the demonstrative partition of the possibility space of the roll of a die,  $\{3, \neg 3\}$  (say). This is a demonstrative partition because it distinguishes 'this' from '¬this' and the partition is in effect  $\{(3), (1, 2, 4, 5, 6)\}$ . The objectivity or subjectivity of this partition depends on the *justification* for the partition. It is easy to identify some subjective feature of (3) that distinguishes it from (1, 2, 4, 5, 6). Imagine winning \$1000 if the die lands 3 on the next roll. Here there is a clear subjective justification to partition the space demonstratively. But I suggest that it is more difficult to identify an objective justification that distinguishes (3) from (1, 2, 4, 5, 6). If we can identify some feature of (3) that distinguishes it in an *objectively significant sense* from (1, 2, 4, 5, 6) then we could consider that the partition is objective. However, I contend that there is no such objective feature. Compare the demonstrative partitions  $\{(3), (1, 2, 4, 5, 6)\}$  and  $\{(4), (1, 2, 3, 5, 6)\}$ . One partition is based on 3 and the other based on 4, but there is no objectively significant feature that justifies the partition based on 3 *as opposed to* 4. Given that there is no obvious objectively significant difference but there is an obvious subjectively significant difference, I assume that the difference is subjective, at least

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<sup>54</sup> Note here that the partition  $\{1, 2, 3, 4, 5, 6\}$  is not the only objective non-demonstrative partition. Each face of the die has the possibility of landing with the orientation of the numeral lying 'north-south' or 'east-west' or any other bearing. I could choose to partition the space also taking each of these possibilities into account. But as long as the partitions were based on regular divisions the partition would remain objective.

until objective significance is demonstrated. In summary, I take non-demonstrative partitions to be fundamentally objective, and I take demonstrative partitions to be fundamentally subjective unless proven otherwise. The assumption that non-demonstrative partition naturally implies objectivity and that demonstrative partition naturally implies subjectivity allows for a powerful analysis of the possibility space of universes.

#### *4.3.6 Choosing and justifying a partition: demonstrative or non-demonstrative?*

We have two ways to partition the possibility space. Now consider why we might choose to partition the space either demonstratively or non-demonstratively. Choosing to partition non-demonstratively seems natural. If there are six faces on a die then it seems natural to partition the space non-demonstratively to distinguish these six possibilities.<sup>55</sup> But choosing a demonstrative partition seems to be motivated by subjective interest, as illustrated above in the gambling example. Winning \$1000 if the die rolls 3 would be a reason to partition the space demonstratively  $\{3, -3\}$ . Notice that demonstrative partition is based on interest or *significance*. If we have an interest in a particular outcome (or type of outcome) then we might choose to partition the space demonstratively. So if we have an interest in a particular possibility (or type of possibility) then we may want to partition the space to map this interest. But other people might not share our interest in a certain possibility. So others may not wish to partition the space using the same partition. In this sense, partitioning the space demonstratively is a subjective exercise. We may be interested in some feature of the possibilities that has significance to us (winning if the roll is 3) and this is reasonable. But it is subjective motivation driving the demonstrative partition and it is important that the subjectivity be recognised as such.

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<sup>55</sup> The roll of a die can be represented by a finite discontinuous possibility space. Non-demonstrative partition of a finite discontinuous space is straightforward, but non-demonstrative partition of continuous possibility space (and infinite discontinuous space) is technically more challenging due to the infinity of points in the space. To minimise this problem I can partition the space using regions rather than points. In this situation I simply partition the space using equal regions. Although technically more involved, the non-demonstrative partition of spaces involving infinities is as natural as the partition of discontinuous possibility space.

How does this relate to partitioning the possibility space? I see non-demonstrative partition as objective. So a decision to partition the possibility space using a non-demonstrative partition is equally objective. However, I see demonstrative partition as essentially subjective, so any choice to partition the space demonstratively would be justified by subjective reasons. Any claim of *objectivity* for demonstrative partition needs to be argued for. Without reasonable justification the objectivity of the partition is questionable. Consider the situation in which two people are choosing the appropriate partition of a probability space. Given the objective nature of a non-demonstrative partition I would not imagine them having difficulty agreeing to partition the space in this way.<sup>56</sup> However given the subjective nature of demonstrative partition, if the two people disagree on the significance of the features in question they may disagree on the appropriateness of the partition. For example, if I am the person who stands to win \$1000 if the die lands 3, it is understandable that I may wish to partition the possibility space demonstratively as follows  $\{3, \neg 3\}$ . But you, as a disinterested bystander, may have no interest in this partition. You may see the most appropriate partition as the non-demonstrative one  $\{1, 2, 3, 4, 5, 6\}$ . In general then, if a demonstrative partition is subjective and the significance of the partition is not recognised by all those involved then the justification of the choice of the partition is undermined.

#### *4.3.7 Identifying the members of a demonstrative partition*

Another issue for demonstrative partition is identifying the members of the partition. Identification of membership in a non-demonstrative partition is not problematic. This is simply a case of putting every distinct possibility in a separate partition (or specifying the co-ordinate boundary if finite volume partitions are being used). But the determination of membership in a demonstrative partition is more of a problem. The partition is not necessarily based on well-defined features of the elements of the possibility space. It is based on the distinction between 'this' and 'not this'. It may be unproblematic, if there is a clear understanding of what 'this' is. But if 'this' is not well-

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<sup>56</sup> In principle there is the possibility of gerrymandering the non-demonstrative partition, but only if the *regular* nature of the partition is compromised.

defined it may be difficult to identify the members of the partition. For example, consider the demonstrative partition {hard,  $\neg$ hard}. It is not at all clear that such a division is objectively well-defined. Without a well-defined objective division any choice of members of the partition will be problematic.

#### 4.4 Possible universes

##### 4.4.1 *The possibility space of universes: continuous or discontinuous?*

How could the universe have been different? The answer depends on the structure of the ontic possibility space. If universes can be different at all, then they can differ in (at least) two ways. Either, they can vary continuously or discontinuously. Take a universe to be specified by the laws of nature that operate in it together with the initial conditions of that universe. The laws that operate in this universe (and the initial conditions) are specified using numbers.<sup>57</sup> We can specify a different universe by using a different set of numbers in the laws of nature and/or in the specification of the initial conditions. Take any real number that appears in a law or initial condition of this universe and replace it with another real number. This will specify a different universe. But are all the different universes that we can specify in this way ontically possible? This depends on how the possibility space is structured. In the fine-tuning debate it seems acceptable to replace a real number with another real number in order to specify a different law of nature (or initial condition) and thereby specify a different universe (Hawking 1989) 132. But this may not be appropriate. Just because we can conceive of numbers in the laws and initial conditions holding any (positive) value on the real line, this does not imply that these conceptualisations correspond to ontically possible laws and initial conditions. Although the real numbers range infinitely and continuously this does not justify the assumption that there is an infinite number of ontically possible universes. There may be universes specified using numbers in this way that simply do not correspond to any that is

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<sup>57</sup> Perhaps universes can be specified without the use of numbers. Hartry Field has argued that all Newtonian science can be done without numbers (Field 1980).

ontically possible. If the ontic possibility space of universes is structured discontinuously then some universes are not ontically possible.

This distinction relates to the existence of mathematical artifacts, and the issue, of whether mathematics in laws is *ontic* or *epistemic*. Mathematics may be a characteristic only of the description of the universe or it may be a characteristic of the universe itself. Recall also the analogy of the map and the territory. Patterns of ink are a characteristic of the map. We can change the patterns of ink on the map, but this does not imply anything about the territory. If we assume that mathematics is only a characteristic of the description of the universe, then it is a characteristic only of the map. We can change the real numbers in the description of the universe, but if mathematics is not a characteristic of the universe itself, changing numbers in the description implies nothing about other ontically possible universes. The nature of the ontic possibility space of universes will not be settled here, but it is important for our purposes that we understand how this specifies what types of universe are ontically possible.<sup>58</sup>

#### *4.4.2 Partitioning the space of possible universes*

The possibility space of universes can be partitioned non-demonstratively or demonstratively. Consider non-demonstrative partition first. One obvious foundation of the non-demonstrative partition is the numbers associated with the laws of nature and initial conditions of the universe. There are two options for this partition. The first is that each distinct universe can be partitioned individually. If the possibility space is discontinuous, then this is a reasonably manageable process. However if the space is continuous this is technically challenging. Due to the nature of the space, even in a finite volume, there will be an infinite number of partitions. Given a continuous possibility space the best option for the non-demonstrative partition is to use finite volumes of

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<sup>58</sup> I have made the distinction between continuous and discrete quantitative possibility. So I now have two options for the structure of possible universes. But there is still the issue of how far this structure extends. Regardless of whether ontic possibility is continuous or discrete both of those structures could extend infinitely.

space rather than using individual universes. Both these forms of non-demonstrative partition can be considered objective.

Now consider the demonstrative partition. One possible demonstrative partition is between life-allowing and life-precluding universes: {life-allowing,  $\neg$ life-allowing}. But just as in the case of the demonstrative partition among rolls of a die, we need to know the *justification* for the demonstrative partition among universes. If the justification for the demonstrative partition is subjective, then the partition itself is subjective. If it is objective, then the partition is objective. I contend that since any justification for the partition {life-allowing,  $\neg$ life-allowing} is subjective, so the partition itself is subjective.

Consider again the roll of two dice. Is there an objective justification for distinguishing rolling a double six in a game of dice from any other combination? If there is a \$1000 bet on the roll, then there certainly is a subjective justification to partition the space demonstratively {double six,  $\neg$  double six}. This is an important point. Demonstrative partitioning is fundamentally related to significance. If there is no *significance*, then there may be no *justification* for a demonstrative partition. If there is significance, this may be subjective or objective. If the significance is subjective, then the justification of the demonstrative partition is equally subjective. If the significance is objective, then the justification of the demonstrative partition is equally objective. But identifying the objective significance of the partition {life-allowing,  $\neg$ life-allowing} is not easy. Scriven has illustrated the subjective nature of the demonstrative partition of universes in the following passage.

If we decide to throw a die ten times, then it is guaranteed that a particular one of  $6^{10}$  possible combinations of ten throws is going to occur. Each of them is equally likely; each of them is entirely distinct from each other possibility. And each of them, if we study it closely, has interesting properties. Now it would be pretty silly for the combination that happens to come up, to sit and look at itself and suggest that there had to be a designer who deliberately manipulated the fall of the die in order to bring about the particular combination that did occur (Scriven 1966) 129.

Let me translate this passage into my terminology. Using a non-demonstrative partition we can separate each of  $6^{10}$  possible combinations into separate partitions and this is

unproblematic. Now consider a demonstrative partition. If we choose a demonstrative partition what will we base it on? As Scriven notes, each combination has interesting properties, so there does not seem to be any objective justification for a demonstrative partition. Then Scriven imagines the situation where the combination that comes up sits and 'looks at itself and suggests that there had to be a designer'. This is equivalent to the combination 'choosing' to partition the space demonstratively in the following way, {itself,  $\neg$ itself}. This demonstrative partition is clearly subjective and not justifiable on any (obviously) objective grounds.

#### *4.4.3 Life-allowing universes*

For argument's sake, assume that some universes do, and some universe do not allow for life. So we could partition the possibility space demonstratively using the following partition: {life allowing,  $\neg$ life allowing}. But why would we select this partition? One reasonable justification is our interest in why the universe allows for life, and this partition might help answer that question. But note that this partition is based on *subjective* interest. The fact that this universe allows for life is of significance to us, and we can justify this partition subjectively, simply by declaring an interest. However, in order to justify an objective demonstrative partition we need to identify objective significance. But there is no obvious reason why a universe that allows for life is *significant* in any objective sense. There are certainly objective *differences*. But in order to justify the objective *demonstrative* partition there needs to be objective significance. In other words, to claim the demonstrative partition is objective, we need to justify the significance of the partition on objective grounds. To do so we need to identify the objective significance of life. The importance of this point cannot be understated. There are reasonable grounds to make a demonstrative partition based on subjective significance. But this does not mean that there is any objective justification for this partition. To justify an objective demonstrative partition, the objective significance of life would need to be demonstrated. So, is life objectively significant?

#### 4.4.4 *Is life objectively significant?*

This is an interesting question, and I will not come to any definitive answer here. However, let me state my position on objective significance. I do not think that life (or anything else) is objectively significant. But this is not due to any characteristic (or lack thereof) of life. Consider the notion of significance. I take significance to imply teleology or purpose. A state of affairs is significant *in relation to some purpose*. If a purpose is subjective, then a state of affairs is subjectively significant in relation to that purpose. If a purpose is objective, then a state of affairs is objectively significant in relation to that purpose. I will not argue for the following position here, but I see no reason to assume the existence of objective purpose. In the absence of any objective purpose there can be no objective significance, only subjective significance.

I believe the whole fine-tuning debate is ultimately motivated by the question of whether life (or perhaps more accurately, intelligent life), is objectively significant.<sup>59</sup> If (intelligent) life is objectively significant, then it seems to me that the existence of (intelligent) life should be necessary. Or at the very least if (intelligent) life is objectively significant, then the fine-tuning requires explanation. If (intelligent) life is not objectively significant then the fine-tuning does not require explanation. Or equivalently, chance is a suitable explanation. But importantly, to *define* objective significance based on objective purpose, and then to use that objective significance to *argue for* objective purpose (in the form of God) is circular.

Additionally, if (intelligent) life is objectively significant, then we need to ask: why? One answer relies on God. Swinburne argues that God would want intelligent organisms (Swinburne 1991) chapter 9. But reliance on God leads to the Euthyphro dilemma. Is (intelligent) life objectively significant because God wants it? Or does God want

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<sup>59</sup> The fine-tuning debate could be characterised as simply about 'life', but it seems to me that most advocates in the debate, implicitly or explicitly, have *intelligent* life in mind (Swinburne 1991) 301, (Davies 2003) 151.

(intelligent) life because it is objectively significant? If (intelligent) life is objectively significant because God wants it, then any argument from the existence of (intelligent) life to God would be circular. Alternatively, if God wants (intelligent) life because it is objectively significant, then the objective significance of (intelligent) life is independent of God. If this is the case, the objective significance of (intelligent) life still needs to be demonstrated.

For the purposes of this discussion I accept that life is subjectively significant and that this is uncontroversial. However I maintain that the objective significance of life (if it exists at all) has not been demonstrated. Finally by way of illustrating the subjective nature of the significance of life, recall the gambler and the bystander. Notice that a double six *means* completely different things to a person involved in the bet and to a disinterested bystander. Consider the situation if *you* have just placed a bet of \$1000 on a roll of the dice. The outcome of that roll *means* something to you. It may mean that you lose \$1000 or it may mean that you win a large sum of money. Now consider the situation if you were *literally* a disinterested bystander. The outcome of that roll means nothing to you.

#### *4.4.5 Partitioning life-allowing universes*

What is the (subjectively) significant difference among universes? This universe allows for life.<sup>60</sup> And it seems that if this universe were slightly different then life would not be possible. Most people find this significant. So the demonstrative partition that we are interested in is the partition that separates 'life-allowing' universes from 'life-precluding' universes. So how do we separate the life-allowing universes from the life-precluding universes? We need to know what it is about a universe that makes it life allowing. What is the nature of the difference on which the demonstrative partition is based? The short answer is that we don't know. We know what makes this universe life

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<sup>60</sup> Two points need to be made here. Firstly, the characteristic that I am interested in may not be that 'this universe allows for life', but more specifically that 'this universe allows for our kind of life'. And secondly, it is interesting to ponder the fact that this universe does not appear to *ensure* the existence of life. If life had not arisen, would this 'life-allowing' universe still have been significant?

allowing: it is the fine-tuning. So we can put our universe in the life-allowing partition.<sup>61</sup> But what other universes belong in the life-allowing partition? We can include the other universes that are arbitrarily close to our universe, with respect to the life-allowing values.<sup>62</sup> But what about universes that are not arbitrarily close to our universe? We know that universes that are *slightly* different are life-precluding. So we can put those in the life-precluding partition. But as we move from 'slight' to 'substantial' differences we encounter problems. When it concerns the 'life-allowing-ness' of distant universes we know very little. We have little idea what other universes with substantially different values would be like. We can partition the local universes into life-allowing and life-precluding. But that is about all we can do. And there are large numbers of possible universes that remain unpartitioned.

#### 4.4.6 *What universes are life allowing?*

The problem is that we do not know what other types of life are possible in other (substantially different) types of universe.<sup>63</sup> To partition the space we need to know the definition of life. Unfortunately there is no unproblematic definition of life (Feldman 1995), (Sterelny and Griffiths 1999) 357. It is possible to list the characteristics of 'living things'. Living things are highly organised. Living things exhibit homeostasis. Living things reproduce, grow and develop. Living things take energy from the environment and change it from one form to another. They respond to stimuli and they are adapted to their environment (Curtis 1983) 18-19. But this does not help, because we do not know whether other, significantly different, universes would allow for life as we described it.

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<sup>61</sup> If I stopped here I would simply have the following partition, {this universe,  $\neg$ this universe}. But this partition is based on nothing more than the observer selection effect, and is not significant in any interesting sense.

<sup>62</sup> Although the assumption in the debate is that 'slightly different' universes are not life-allowing, there are 'different' universes with 'arbitrarily close' values for the fine-tuned parameters that remain life-allowing.

<sup>63</sup> A further complication is that, of the life-allowing universes, I do not know which allow for *intelligent* life. But let me put aside this complication.

One approach in the fine-tuning literature focuses on carbon-based life (Colyvan, Garfield, and Priest). If we define it strictly as carbon-based life, then we have a clearer idea of the type of universes that would allow for it. But do we really want to define life only as carbon-based? What is so special about carbon? Recall the characteristics of living things. Any universe that allowed for such structures would be a life-allowing universe. If we define life only as carbon-based, then we will exclude universes that allow for other forms of life, universes that may be equally deserving of a place in the life-allowing partition. In short, apart from the local area of universes, we do not know what parts of the possibility space to include in our partition and what parts of the possibility space to exclude. We may try to demonstratively partition the whole possibility space into life-allowing and life-precluding universes. But we cannot do this. All that we can do is partition the local area of possible universes.

We know that there is one region of life allowing universes, or possibly more; recall the research noted by (Leslie 1989) 53 and (Collins 2003) 185. The rest of the local area is, as far as we know, life-precluding. But what are the implications of this information? Some might argue that this information has no substantive implications because we do not know if it is representative of the total possibility space (Colyvan, Garfield, and Priest; Fulmer 2001). But this is too extreme. It is not as if we *know* that distant areas are life-allowing and these areas are deliberately *excluded* from the data. The best information we have about life-allowing universes is considered in this debate. We simply lack knowledge about distant regions; we only have information about the local area. So if we want to partition the local area we can do so. Life-allowing universes appear to be rare in the local area. But whether this means that life-allowing universes are rare in the total ontic (and perhaps even logical) possibility space is now, and for the foreseeable future, an open question.

#### *4.4.7 Leslie's 'local area' argument*

There is another approach we can take; consider Leslie's 'local area' argument.

... you mustn't attack anthropic reasoning by saying that it involves making claims about the rarity of Life and Intelligence in the field of all possible universes. Yes, any such claims might indeed go too far beyond our

evidence; but the user of anthropic reasoning need not make them, as shown by the tale of the Fly. If a tiny group of flies is surrounded by a largish fly-free wall area then whether a bullet hits a fly in the group will be very sensitive to the direction in which the firer's rifle points, even if other very different areas of the wall are thick with flies. So it is sufficient to consider a *local area of possible universes*, e.g., those produced by slight changes in gravity's strength, or in the early cosmic expansion speed, which reflects that strength. It certainly needn't be claimed that Life and Intelligence could exist *only if* certain force strengths, particle masses, etc. fell in certain narrow ranges. For all we know, it might well be that universes could be life-permitting even if *none* of the forces and particles known to us were present in them. All that need be claimed is that a lifeless universe would have resulted from *fairly minor changes* in the forces etc. with which we are familiar.

When imagining such changes we limit our thought-experiments to a local area of possibilities which cosmologists can and do discuss with some confidence. Like it or not, they have actual scientific grounds for saying, e.g., that a slight increase or decrease in early cosmic density would have spelt disaster (Leslie 1989) 138-139.

Leslie makes an important point here, the significance of which has not been widely appreciated in the literature. If we follow Leslie, then it is *not* the fact that the universe *allows* for life, it is the fact that the universe is *fine-tuned* for life that matters. It is the fact that, if the universe were *slightly different* then life would not be possible that is crucial. Consider two distinct life-allowing universes in the possibility space of universes. Figure 4:1 below represents the possibility space of universes; Life-allowing universes are the high points. The first universe (A) is such that all the universes that are slightly different from it are not life-allowing. This universe is fine-tuned for life. The second universe (B) is such that all the universes that are slightly different from it are also life-allowing. This universe is not fine-tuned for life. So although both universes are life-allowing only one is *fine-tuned* for life.



*Figure 4:1 Fine-tuned or not fine-tuned?*

So we can demonstratively partition the possibility space of universes; one for universes

that are *fine-tuned* for life and another for universes that are *not fine-tuned* for life. (The second partition may contain many universes that *allow* for life, but these universes would not be *fine-tuned* for life.) We can demonstratively partition the local area in this way. We can put our universe (and other universes arbitrarily close to it) in the fine-tuned for life partition and we can put all the other 'slightly different' universes in the not fine-tuned for life partition. But again, when it comes to universes that are substantially different from ours (i.e., not in the local area), then we just do not know what they are like. It could be that if a universe *allows* for life, then it must also be *fine-tuned* for life. Perhaps all life allowing universes are fine-tuned, meaning that all the universes that are slightly different from each life-allowing universe are not themselves life-allowing. Alternatively, there could be vast contiguous regions of possibility space that correspond to life-allowing universes. We can sort the local area of possibility space into universes that are 'fine-tuned for life' and those that are not. But that is all we can do, and there is a great deal of possibility space remaining.

It needs to be stressed that Leslie is not concerned with the total possibility space. He is not concerned with the nature of distant possibility space. He is concerned only with this universe and the fact that this universe is *fine-tuned* for life. Leslie considers the fact that this universe is fine-tuned for life is *in and of itself significant*. The significance or otherwise of the fine-tuning is an important issue that informs much of the fine-tuning debate. Those who see life as significant tend to find the fine-tuning surprising (Swinburne 1990), while those who do not see life as significant tend not to see the fine-tuning as surprising (Scriven 1966) 129. As will be seen the surprising-ness or unsurprising-ness of the fine-tuning is an elusive concept.

#### *4.4.8 Life-allowing or fine-tuned for life?*

There is an important point here that is easy to overlook. If the universe allowed for life but was *not fine-tuned* for life, then we may not be motivated to explain the life-allowing nature of the universe. Swinburne argues that for the tuning to be evidence for God, it must be rare in the total (logical) space of universes (Swinburne 2004) 185. It is the fact that the universe allows for life *and* that other slightly different universes do not allow for life that motivates the debate. But underlying this is the fact that life is considered

significant. If life were not considered significant, then there would be no motivation to explain it. To illustrate the central role significance plays in this debate consider an example of fine-tuning that is not significant. Imagine walking along a steep canyon. The trail we are on is roughly half way up the canyon wall, such that we can neither see the canyon floor nor the canyon edge above. We notice (some way ahead), a rock pillar that stands a good distance from the canyon wall. As we approach the pillar we see a rock bouncing down the canyon wall from above. This rock bounces in such a way as to land on the top of the pillar and, as it happens, the rock stays there. This is a case of fine-tuning that is not a significant event. The event is fine-tuned, because if the rock had fallen slightly differently, then it would not have landed on the top of the pillar. But fine-tuning *per se* is not enough to motivate explanation. It does not motivate us to seek an explanation because the event is of no significance.<sup>64</sup>

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<sup>64</sup> Leslie has used the Fly on the Wall Story to illustrate this point. But talk of bullets does tend to suggest a marksman. I have tried to provide an unbiased illustration, but my choice may bias chance. It is interesting to note that Leslie uses the example of a "boulder whose bouncings were all 'directed towards' its arrival in the valley", as a contrast to the 'directed' nature of life (Leslie 1989) 117. However, I see no such difference between the 'directed' action of the boulder, and the 'directed' action of living organisms. Both systems are simply the result of physical processes.

## 5 The Nature of the Possibility Space of Universes

### 5.1 Preliminaries

#### 5.1.1 Responsible speculation?

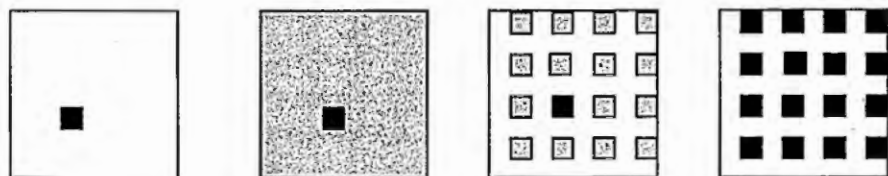
I now have an account of the nature of possibility space in general and the options for partitioning that space. I will apply this account to the fine-tuning of the universe. Here I examine the nature of the possibility space of universes with reference to physical, logical and ontic possibility. In this analysis I will briefly consider the possibility that the structure of the universe is necessary. But it is more plausible to assume that universes structured differently are possible. If we can understand ontic possibility space, then we gain an understanding of what other universes are ontically possible. Understanding ontic possibility space is not an easy task. There is a danger of unsupported speculation. However, I maintain that I can undertake responsible speculation. This speculation turns on the evidence of the fine-tuning that *slightly different universe do not allow for carbon-based life*. All my speculations with respect to ontic possibility space must conform to this data. Using this evidence as a basis I examine two possible structures that could ground ontic possibility space. These speculations are inspired by structures that seem to exist in this universe: *chaotic systems* and *quantised systems*. Both these possible structures of ontic possibility space are consistent with the fine-tuning evidence that slightly different universes do not allow for carbon-based life.

#### 5.1.2 Note on the graphical illustrations

In this chapter I use diagrams to illustrate the concepts considered; for example, Figure 5:1 below. The diagrams illustrate the possibility space. The possibility space considered in the previous chapter was n-dimensional, with each dimension representing a different feature of the possible universes. For practical reasons I use two-dimensional images but these simple diagrams suffice for our purposes.

The diagrams are squares made up of different coloured points (areas). Each point (area) in the square identified by the co-ordinates of that point - imagine an x and a y axis - represents a logically possible universe. So the square represents logical possibility

space. The different colours of each point (area) represent some aspect of the nature of the corresponding universe. Black space represents life allowing universes that are ontically possible. (Our universe exists in this space). Grey space represents universes that are ontically possible but not life-allowing. White space represents logically possible universes that are not life-allowing.



*Figure 5:1 Different possibility spaces of universes.*

Note that the three colours are used to highlight different features of possible universes. The distinction between black space and white space highlights the possibility that some logically possible universes may not be life-allowing. The distinction between black space and grey space highlights the possibility that some ontically possible universes may not be life-allowing. And finally, the distinction between white space and grey space highlights the possibility that some logically possible universes may not be ontically possible. So the important distinctions here are between *life-allowing* and *life-precluding* universes and between *ontically possible* and *ontically impossible* (but *logically possible*) universes.

Two types of diagram are used. The first type contains all three colours. These diagrams represent the situation in which some logically possible universes are not ontically possible. The second type of diagram contains only two colours, white and black or grey and black. These diagrams represent the situation in which all logically possible universes are also ontically possible. In effect, grey space and white space represent the same universes so the distinction between grey and white becomes redundant.

There are limitations to this diagrammatic approach.<sup>65</sup> But it is a powerful way of illustrating the various possibility spaces of universes. These diagrams capture the important distinction between demonstrative and non-demonstrative partitions among possible universes that was used in the previous chapter. Each point (area) in the square, identified by the co-ordinates of that point, represents non-demonstratively partitioned universes. The colour of each point (area) can represent demonstratively partitioned universes. For example, the colour difference (black,  $\neg$  black) represents the demonstrative partition {life-allowing,  $\neg$  life allowing}. Further, the distinction between continuous and discontinuous ontic possibility space can also be easily represented.

To illustrate the use of these diagrams consider Figure 5:1. The first diagram (on the left) represents one or a small number of life allowing universes in the logical possibility space. The second diagram represents one or a small number of life-allowing universes in continuous ontic possibility space. The third diagram represents one or a small number of life allowing universes in discontinuous ontic possibility space.<sup>66</sup> The fourth diagram (on the right) represents a discontinuous ontic possibility space in which all ontically possible universes are life allowing.

### *5.1.3 Possibility spaces consistent with the fine-tuning data*

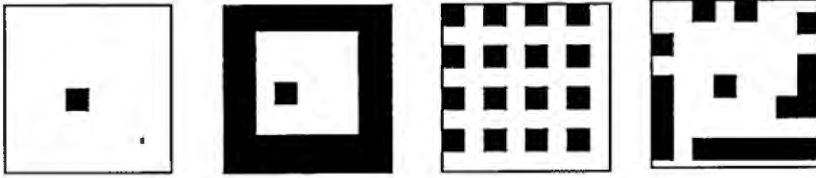
The following diagrams, Figure 5:2 and Figure 5:3, illustrate possibility spaces that are consistent with the data of the fine-tuning. (That this universe allows for life and that universes that are slightly different do not allow for life.) Figure 5:2 does not incorporate the notion of ontic possibility. (Or equivalently all logical possibilities are considered to be ontically possible). Figure 5:3 distinguishes logically possible universes from

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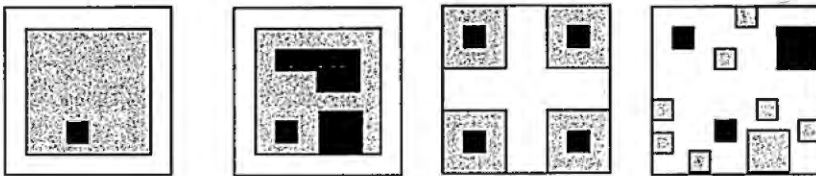
<sup>65</sup> One limitation is that logical possibility space is infinite, but it is represented by a finite area. Another limitation is that logically impossible universes are not represented. Yet another limitation is that life allowing universes that are logically possible but ontically impossible have not been illustrated. In the diagrams that contain all three colours, there is a hierarchic structure, black *in* grey *in* white. This structure does not allow for the illustration of black areas that are not also in (or co-extensive with) grey areas.

<sup>66</sup> This graphical representation of discontinuous ontic possibility space has used grey areas on the page. These areas on the page are divisible. But let me assume that these areas represent discrete universes.

ontically possible universes. This illustrates the possibility that there may be universes that are logically possible but ontically impossible.<sup>67</sup>



*Figure 5:2 Actual and possible life-allowing universes in logical possibility space*



*Figure 5:3 Actual and possible life-allowing universes in ontic possibility space.*

## 5.2 Getting to know the territory

### 5.2.1 *Is the fine-tuning necessary or contingent?*

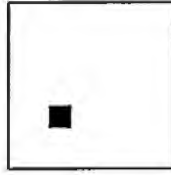
Talk of other possible universes is pointless if this universe is necessary. So first consider whether this universe is necessary or contingent. Here we need to be careful about the nature of the necessity. We are not attempting to answer the question: why is there something rather than nothing? We are not considering whether the universe is necessary in that sense. Rather we are considering whether, if there is a universe at all, it necessarily has the properties of the actual universe.

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<sup>67</sup> Note that where all logically possible universes are ontically possible (the upper row of diagrams without grey) all the life-allowing universes have been illustrated. However, where all logically possible universes are not necessarily ontically possible (the lower row of diagrams with grey), life-allowing universes that are logically possible but ontically impossible are not depicted. There may be logically possible life-allowing universes in the white area, but as these are not ontically possible, they have not been depicted.

Further, to consider this we need clarity about what modality we are working with. First, let me discount physical necessity/contingency. Physical modality is what is necessary/contingent given the laws and initial conditions of the universe. But these are the very things we are considering to be different. So, physical modality is irrelevant. Now consider logical modality. This fine-tuned universe does not seem to be logically necessary. Consider a universe with one kilogram more of matter, or one kilogram less. This difference does not appear to lead to a logical contradiction (Lycan 2002) 311. So we can conceive of the universe being otherwise without obvious contradiction. The lack of any known contradiction supports the assumption that other universes are logically possible. Of course, we could be wrong; the different universes that we conceive could be self-contradictory. But it seems more reasonable to accept that there are other logically possible universes, and that the properties of this universe are logically contingent. So logical modality is relevant here.

Now let us turn to ontic modality. The fine-tuning is ontically possible because it is actual. But we do not yet know if it is ontically necessary. It may be that this universe is the only ontically possible universe. Hawking has developed a proposal, called the 'no boundary proposal', according to which the *initial conditions* of the universe are necessary (Hawking 1989) 184. Although Hawking admits that the laws could still be contingent, further developments in physics may lead to a theory that uncovers necessity in the laws themselves. If such a theory is true, then the fine-tuning of the universe could not have been other than it is. So there would be no *tuning* of the universe, let alone *fine-tuning*. This universe would be the only ontically possible option. This is not to say that the universe had to exist; only that if it existed, then it could only exist in this form. If this were the case, the possibility space of the universe would look like Figure 5:4. The black square represents this unique ontically possible fine-tuned universe. The larger white square represents other logically possible universes. While these other universes are logically possible they are ontically impossible. If physicists uncover necessity in the laws of nature this will be significant. But for now assume that the fine-tuning is ontically contingent.

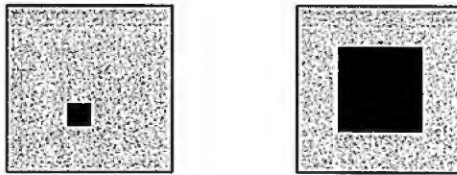


*Figure 5:4 Life allowing values as the only ontic possibility.*

So what modality are we working with? We have excluded physical possibility but logical and ontic modalities both seem potentially appropriate. The next task is to examine the nature of the logical and ontic possibility spaces of universes. If the fine-tuning could differ, in what ways could it differ? But before we address this question we need to consider the notion of ‘slight difference’.

#### *5.2.2 How ‘slight’ is a slight difference?*

The term ‘slight difference’ is problematic, as already noted by various authors (Manson 2000; Colyvan, Garfield, and Priest; Clifton 1991). The problem is that ‘slight’ is a relative term; it depends on the context in which it is applied. Consider the Figure 5:5, the black area represents a universe or universes that are life-allowing, and the grey area represents ontically possible universes that are not life-allowing.



*Figure 5:5 Fine-tuning or Coarse-tuning?*

Consider the situation on the left. Assume that the universe holds ‘fine-tuned’ values that locate it in the black square. If these values are changed ‘slightly’ (imagine changing vertical and horizontal co-ordinates), then the new universe may well be located in the grey area and would thus be a life-precluding universe. Now consider the situation on the right. Again assume that the universe holds values that locate it in the black square. If these values are changed by the same ‘slight’ amount, then the new

universe may well *still* be located in the black area. (This is subject to its original location, but let us assume that it began somewhere near the middle.) The problem here is that the word 'slight' is used without a context. The term 'slight difference' is only applicable to differences *relative to* the total range over which the value varies. If we do not know the total range over which the value varies, we cannot use the phrase 'slight difference'. Consider a difference of one centimetre in the position of an object. Is this a slight difference? We can only answer this question if we know the context. If it is in relation to the position of an electronic component of a modern computer this is not a slight difference. But if it is in relation to the position of a car in a parking space it is a slight difference. This point prompted Clifton to draw the distinction between fine-tuning and 'coarse-tuning' (Clifton 1991) 30. If upon further empirical investigation the apparently 'fine-tuned' parameters are really only 'coarse-tuned' the fine-tuning debate is undermined.

### *5.2.3 The fine-tuning as contingent*

Now we examine in detail logical and ontic possibility space. The first issue is where to start. We know that this universe is both ontically and logically possible. So in one sense this universe is a safe place to start. But in another sense it is dangerous. The danger is that our starting point is *biased* by the observational selection effect. Ours is the only universe we observe, but this does not necessarily make it a good place to begin our exploration of logical and ontic possibility. However we have little choice. So with possible bias in mind, we start from the realities of this physical universe. We can start with physical possibility and use what we know about it to inform speculation about logical and ontic possibility. Aspects of the physical universe may help us understand the nature of the fine-tuning in logical and ontic possibility space.

Let us begin with logical possibility. Assume that the laws of nature could take any logically possible form. Given this, there are infinitely many ways that the laws could be different. Any of the numbers in the laws could vary, or the laws could take completely different forms. If we assume that the numbers in all the laws could be any real number

(as seems to be logically possible), then clearly the field is infinite.<sup>68</sup> But what is the nature of this infinite possibility space? The simple answer is that we do not know. To understand this, let us now consider what Fulmer calls a ‘fatal flaw’ in the fine-tuning argument (Fulmer 2001).

#### *5.2.4 Beyond the local area*

Fulmer acknowledges that the fine-tuning of the universe implies that a universe with almost exactly the same laws and constants as our universe could sustain life and that a universe with slightly more different laws and constants could not. But he points out that it does not follow that a universe with still greater differences in laws and constants could not sustain life. He notes that a universe with different laws and constants may in fact be more suitable for life. He stresses that claims about other universes based on science are meaningless.

The [fine-tuning argument] claims to show scientifically that a different universe could not support life; but scientific calculations about conditions in hypothetical very different universes are meaningless, since their only possible basis is the laws and constants of the universe we know. Therefore, they can tell me nothing about the probability of life in actual or possible universes with different fundamental laws or constants. Such hypothetical other universe might be as good as or better than this one for sustaining life (Fulmer 2001) 102.

The simple fact is this. Just because *slightly* different values do not allow for life does not also imply that *substantially* different values do not allow for life. Consider Figure 5:6: The left hand diagram illustrates the traditional interpretation of the fine-tuning data. But as Fulmer points out there is no reason to assume that distant regions could not support life.

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<sup>68</sup> And this does not take into account different laws.



*Figure 5:6 Beyond the local area: empty or chaotic complexity?*

Admittedly, it may be a very different form of life, but life, none the less. In fact in his fly analogy Leslie has acknowledged the idea that distant regions may be life-allowing.

If a tiny group of flies is surrounded by a largish fly-free wall area then whether a bullet hits a fly in the group will be very sensitive to the direction in which the firer's rifle points, even if other very different areas of the wall are thick with flies (Leslie 1989) 138.

The second diagram from the left illustrates Leslie's local area idea. Leslie's local area argument is not uncontroversial and we consider it in detail when we consider the probability of the fine-tuning but for now let us accept the possibility that distant regions may be life-allowing. Keeping in mind Fulmer's and Leslie's comments, let us return to the nature of logical possibility space. Specifically, consider the possibility that distant regions are life-allowing. If this were to be the case, what might this imply about the nature of logical possibility space?

### **5.3 Chaotic and quantised possibilities**

#### *5.3.1 Chaotic logical possibility space*

Chaos theory may provide the answer. Chaos theory is related to the mathematics of non-linear systems (Gleick 1988). One of the central characteristics of these systems is 'sensitivity to initial conditions'. Slight differences in the starting conditions result in substantial differences as the system evolves over time. Another of the central characteristics of non-linear systems is the distinction between simplicity and complexity. Non-linear systems can move in and out of chaotic behaviour. The evolution over time of a system in a non-chaotic state will be relatively simple. However the evolution over time of a system in a chaotic state will be more complex. Notice that

these two ideas of 'slight difference', and the distinction between simplicity and complexity are also central to the fine-tuning debate. The 'slight difference' issue in the fine-tuning debate is clear enough. Universes adjacent to each other in the possibility space can be considered 'slightly different'. But the simplicity versus complexity issue needs some more examination to become clearer. Universes can be complex or simple and this distinction depends on the laws. The values of the parameters in laws may dictate whether the universe is a complex (chaotic) universe or a simple (non-chaotic) universe. Our universe allows for complexity and this complexity is produced by the characteristics of its laws. If the laws were different, then the universe might be much simpler. Combine this idea with the slight difference idea and note that a slight difference in the laws of a universe can change it from one that allows for complexity to one that is very simple. This is what we find in the fine-tuning of this universe. Although note that while chaotic systems in the physical world 'evolve over time' there is no temporal dimension to the possibility space of universes. The simplicity or complexity of any universe is a manifestation of its location in ontic possibility space.<sup>69</sup> Thus chaos theory may help show how slight changes in the laws and initial conditions of the universe would make life impossible. It is also important to highlight that slight changes from *any* position in a chaotic system result in substantial differences. So our universe would not be unique in being 'fine-tuned' in this way. If the structure of the universe were generated by a non-linear system (and we are considering a chaotic region of that system), then if we compare *any* set of laws with a *slightly* different set, the two universes would look very different. The implication of this *could be* that life-allowing universes (i.e., universes that allow for complexity) are *very common* in the possibility space. But importantly, they do not occur *next to each other*.

Consider any universe that is complex enough to allow for observers (intelligent life). When those observers consider other *slightly different* possible universes in their local area, those universes will be substantially different from the observer's own universe.

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<sup>69</sup> If some form of non-linear system is the ontic ground of universe generation, then this non-linear system does not evolve through time. But it may evolve through a 'higher' dimension.

Given that these other universes are substantially different, they may not be complex nor allow for observers. Given that non-linear systems are now taken to be common in the physical world, there is no reason not to look for them in the generation of the universe itself. All four diagrams above can be considered as an approximate representation of such systems.<sup>70</sup> Although slightly different universes are not life-allowing, life-allowing universes (universes that allow for complexity) may be very common in the total possibility space. So chaos theory may give us some idea of the nature of the logical possibility space of universes.

### *5.3.2 Logical possibility space or ontic possibility space?*

Setting aside the idea of a chaotic logical possibility space, now consider ontic possibility as a possibility space 'wider' than physical possibility space but 'narrower' than logical possibility. The concept of a possibility space 'between' physical and logical is contentious. Some in the fine-tuning debate claim that beyond physical possibility the only reasonable option is logical possibility (Colyvan, Garfield, and Priest *forthcoming*).<sup>71</sup> Perhaps this position assumes that logical possibility has a privileged status, but does it have such a status? Logical possibility is merely all that is non-contradictory. Why does this characteristic afford it any status at all? I contend that while logical possibility limits the possibilities to those that are not self-contradictory, this does not help us understand the nature of the contingency of our universe in any substantive way.<sup>72</sup> I am not interested in what is merely logically possible. I am interested in what is really possible.

Further it is argued that any limitation of the possibility space to less than the logically possible is arbitrary and unjustified (Colyvan, Garfield, and Priest *forthcoming*). While

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<sup>70</sup> The best way to illustrate these ideas is in the form of fractal geometry. One of the most attractive and well-known illustrations of fractal geometry is the Mandelbrot Set. For example see: (Gleick 1988).

<sup>71</sup> (Colyvan, Garfield, and Priest *forthcoming*) initially consider physical, conceptual and logical possibility distinctly, but then appear to take conceptual possibility to be effectively the same as logical possibility.

<sup>72</sup> Here I am bracketing the idea of chaotic logical possibility space.

the charge of the arbitrary construction of ontic possibility space is a justifiable concern, the charge can be met. To act arbitrarily is to act without a reason. But there is a reason. Chaotic systems may be responsible for setting the laws of nature. This was justified by the idea that given chaos operates *in* the laws of nature, then perhaps it operates *on* the laws of nature themselves. I propose that we can postulate the nature of ontic possibility space by extrapolating from what we know about physical possibility. This is simply the application of Ockham's Razor. If we can use what we know about the physical world to understand the ontic, then there is no need to rely on other metaphysical resources. This meets the charge of arbitrariness. I propose the same justification to introduce the idea of a quantised ontic possibility space.

### *5.3.3 Quantised ontic possibility space*

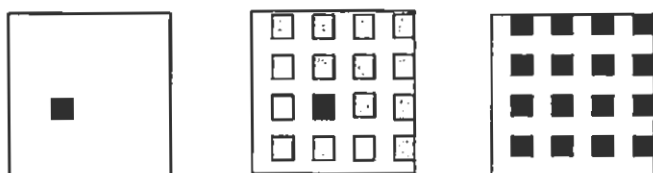
Here I take the concept of quantised possibilities in the physical possibility space and apply the notion to the ontic possibility space. When Planck investigated black body radiation he found that he could get agreement between the theory and his experiment only when he assumed that energy was emitted in discrete 'packets' or quanta (Warren 1983) 65. This idea of quantised energy became central to modern physics. The idea of quantised possibilities may help us understand the fine-tuning of the universe.

If we take logical possibility space, then we assume the fine-tuned variables could take any value on a continuum. But if the constants are subject to quantised limitation, in that they can only hold certain values, then this assumption may not be justified. Again we see the possible role of mathematical artifacts here. There may be values on the mathematical continuum that are ontically impossible for features of possible universes to hold. In fact there is evidence in the physical world that this may be the case. Developments in quantum physics suggest that the possibilities of reality may only vary discontinuously. For example, quantum physics suggests that the world is not infinitely divisible.

Many physicists believe that at Planck dimensions ( $10^{-33}$  cm and  $10^{-43}$  secs approximately) space and time become 'foamy', ill-structured, which rules out infinity of the kind just now considered, infinity of detail in endlessly divisible milliseconds or millilitres (Leslie 1995) 174.

### *The Nature of the Possibility Space of Universes*

Given that our current theories suggest that it is not possible to divide physical space infinitely, consider an ontic possibility space that is also not infinitely divisible. Figure 5:7 is a graphical representation of this idea. The logical possibility space is again represented with a white square, with our universe as part of that logical possibility space. But just as in quantum physics in the physical world, not all of this logical space may be ontically possible. The second diagram represents the discontinuous (quantised) ontic possibility space with our universe in black (in this diagram there are no other life allowing universes in the ontic possibility space). And finally the third diagram illustrates the possibility that every ontically possible universe is life allowing.



*Figure 5:7 Logical and ontic possibility space and life allowing possibilities.*

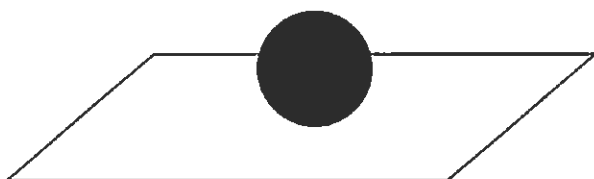
Notice that all these illustrations are consistent with the fine-tuning data. The fine-tuning data is *only* that universes that are slightly different from our own will not be life allowing. If we accept the idea of quantised ontic possibility space, then these slightly different logically possible universes are not ontically possible. If ontic possibility has a quantised structure, it may take a different form from that represented above, but the details of the structure need not concern us. What is significant here is that quantised ontic possibility space is consistent with the fine-tuning data.

This suggestion of the quantised nature of ontic possibility space is epistemologically conservative. Quantised processes exist in the physical world and thus it is justifiable to propose that the generation of the physical world itself may be a quantised process. The potential quantised nature of ontic possibility space is not arbitrary. In fact, one of the main options for explaining the fine-tuning relates to the notion of quantum vacuum fluctuations, and so ontic possibility space may be quantised in nature. If we accept the idea of quantised ontic possibility, then it is no surprise that universes that are *slightly different* from our own are not life-allowing. It is no surprise because they are not even

ontically possible. It was only surprising that slightly different universes did not allow for life because we thought that they were possible. If they are not possible, then the fact that our universe *seems* fine-tuned for life is understandable. Perhaps all ontically possible universes allow for life, but no ontically possible universe is only *slightly* different from any other ontically possible universe, because they are all different by a quantised amount that makes them all substantially different from each other. This would be completely consistent with the fine-tuning data.

#### *5.3.4 An illustration of logical possibility versus ontic possibility*

To illustrate the distinction between continuous logical possibility and discontinuous ontic possibility consider a sphere on a plane (Figure 5:8). The sphere appears free to move on the plane such that any point on the surface of the sphere may touch the plane. Think of this as logical possibility. Notice that there is an infinite number of points on the surface of the sphere that can be in touch with the plane. It is logically possible for any point on the surface of the sphere to be in touch with the plane. *The point of contact between the sphere and the plane can be thought of as the fine-tuned values of the universe.*



*Figure 5:8 A sphere on a plane representing logical possibility*

But now suppose that our perceptions are limited. We perceive a sphere on a plane, but this is not the whole picture. In reality, there is a cube around the sphere such that six points on the surface of the sphere touch the six surfaces of the cube, Figure 5:9. The cube and sphere are two features of the same object and do not move relative to each other. Now there are only six points on the surface of the sphere that can touch the plane. Think of this as ontic possibility. Notice now that there are a finite number of points on the sphere that can be in touch with the plane. It is ontically impossible for any point on the surface of the sphere that is not also on the surface of the cube to be in touch with the plane. *Again the point of contact between the sphere and the plane can be thought of as*

*the fine-tuned values of the universe.* Now the deceptive nature of the fine-tuning is clear. It is only because we do not perceive the cube that we think that there is fine-tuning.



*Figure 5:9 A cube on a plane representing ontic possibility*

### *5.3.5 Quantised ontic possibility space: a proposal*

I use this diagram to illustrate a proposal. We look at all the values that the fine-tuned features could have held and we are amazed they hold values that allow for life. But our amazement may be due to ignorance. Perhaps when we look at 'all the values that the fine-tuned features could have held' we are looking at the sphere. What if we have incomplete knowledge of the system? What if reality is the cube? If we are in fact looking at a sphere *inside* a cube, then it does not seem so amazing. Now, there are only six possible values for the 'fine-tuned' features of this universe. The universe is not really 'fine-tuned' at all. So my 'ontic' proposal is this; ontic possibility space is such that there is not an infinite number of different values that the fine-tuned features of a universe could hold. I propose that ontic possibility space is quantised and quantised in such a way as to make 'slightly different' universes ontically impossible.

## 6 Probability Space

### 6.1 Preliminaries

In this chapter I consider probability and the nature of probability space, and in the next chapter I apply these considerations to the fine-tuning. I begin by examining the probability calculus and interpretations of probability. Then I consider probability as ontic or epistemic. I also examine how the probability space can be partitioned. Following my discussion of partitioning possibility space I consider non-demonstrative and demonstrative partitions. In this chapter I introduce the notion of ‘isoprobability’ for equi-probable events.

In the two previous chapters we examined the notion of possibility. What is the relation between possibility and probability?<sup>73</sup> To clarify this, consider necessity, contingency and impossibility. Contingency is what we most associate with the idea of possibility. But the notions of necessity and impossibility are relevant too, because they define the limits of possibility. In the formal notation of probability, probabilities range from 0 to 1 inclusive. Necessities have a probability of 1.<sup>74</sup> Impossibilities have a probability of 0. And contingencies, or possibilities, have probabilities in the range greater than 0 and less than 1. This is a very brief sketch of the relation between possibility and probability, but it suffices for our purposes.

The study of probability is separable into two distinct areas: the probability calculus and interpretations of probability. The probability calculus can be considered as a tool. It involves certain symbols and rules for their use. But the calculus itself does not explain what these symbols mean. The meaning of these symbols depends on the interpretation of probability (Salmon et al. 1992) 74. So what is ‘probability’? We use probabilistic language frequently and in many different ways. Some senses of the term ‘probability’

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<sup>73</sup> By this question I am not only referring to the classical interpretation, where probability is defined as a simple proportion of the equally possible cases.

<sup>74</sup> Here I am ignoring the distinction some make between logical necessity and a probability of 1 (Fetzer 1970) 479. I assume that the probability of ontically necessary events is 1.

seem well-defined, like the probability of drawing the Five of Clubs from a well-shuffled normal deck of cards, while others seem less well-defined, like the probability that I will catch the last train home if I buy another drink, or the probability of the fine-tuning of the universe. Both in general, and specifically in the fine-tuning debate, it is not always clear what we mean, and indeed if we always mean the same thing. But one thing seems clear. Probabilistic talk typically refers to contingent situations.<sup>75</sup> There are several ways of thinking about contingency: (a) contingency in situations where all the options are well-defined, (b) in situations where the options are not well-defined, and finally, (c) in unique or isolated situations.

### *6.1.1 Contingency and isolated events*

Often probabilistic language relates to 'statistical phenomena' or 'chance setups' (Percival 2000) 367. Tosses of coins, and deals of hands of cards, are common examples. These occur in a specified situation and there are often well-defined alternatives. But these are not the only contingent situations. Many situations are considered contingent because they could have been otherwise. When I will die seems to me to be contingent. But just because we assume that something is contingent, this does not mean that we can specify the other possibilities or even define the situation well.

There is also the issue of the probability of unique or isolated events. By an isolated event I mean an event considered without reference to other events. We can apply the notion of contingency to an isolated event. It seems reasonable to think that an isolated event could have been different. The analysis of isolated events is important in this thesis because the universe itself may be an isolated event. Here there are two ways to think of it. If the universe is the totality of all existence then by definition it is isolated.<sup>76</sup>

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<sup>75</sup> Necessary and impossible events have probabilities of 1 and 0 respectively, thus they are not typically considered probabilistic.

<sup>76</sup> To consider the probability of the totality of existence, I need to consider the probability space in which the totality exists. But if I consider the totality in some larger space am I then no longer considering the totality? This question relates to the hierarchy of logical and ontic possibility space. Is the logical space within the ontic space, or is the ontic within the logical? One possibility is that logical space is actually within the 'totality' but it appears to be outside the totality. The fact that logical possibility appears outside

Alternatively, this universe may be one of a number of universes. However, given that we have no information about other universes it is reasonable to consider this universe in isolation.

Consider the probability of an isolated universe. The first issue is whether it is meaningful to talk of this. Mellor argues that it is meaningless to talk of the probability of the universe, because *ex hypothesi* there is no context in which the whole universe exists that could be used to consider its probability (Mellor 1973) (Mellor 2003).

Alternatively, Lesic argues that even if it is unique, it is still meaningful to consider this universe as contingent, and further to consider the probability of the fine-tuning (Leslie 1989). However, if we want to assess the probability of this isolated universe, it is necessary to locate it in some probability space. The nature of this probability space is central to the fine-tuning debate because it defines the probability of this universe.

## 6.2 The probability calculus

The probability calculus is a powerful mathematical tool that originated in the seventeenth century, as an attempt to improve decisions in games of chance. The current orthodox axiomatization rests on the work of A. N. Kolmogorov in the 1930's (Kolmogorov 1950).<sup>77</sup> But I will note some central aspects of the formal structure. The calculus can be understood in reference to propositions, sentences, events, or sets (Kyburg 1970) 12-13. Here I consider the probability calculus with respect to events. The basic primitive of the probability calculus as standardly presented is the absolute probability of an event. This is represented as  $P(A)=\alpha$ , where  $A$  is the event and  $\alpha$  is the probability of the event. The numerical values of probabilities range from 0 to 1 inclusive. An impossible event has a probability of 0 and a necessary event has a probability of 1. Contingent events range from greater than 0 to less than 1. In a

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the 'totality may be because logical possibility space is a 'logical artifact' generated by our epistemic processes. This relates to the point made by Mellor that it is inappropriate to consider the probability of the totality of existence, because there is no 'chance set up' outside the totality of existence (Mellor 1973) 476.

<sup>77</sup> For a presentation of the calculus see (Hájek and Hall 2002) 157.

probability space comprised of a finite set of mutually exclusive and exhaustive events, the probabilities of all the events sum to 1.<sup>78</sup> In addition to the notion of absolute probability, there is the notion of conditional probability. Conditional probability is the probability of an event conditional on some other event (or circumstance). This is represented formally as  $P(A/B)=\alpha$ . In this situation A is an event and B may be an event or a set of circumstances and here  $\alpha$  is the numerical probability of A, *conditional* on B. The probability calculus is a set of axioms and derived theorems based on these absolute and conditional probabilities. The calculus can only tell us unknown probabilities by calculating these from known (or postulated) probabilities. Bayes' Theorem is a good example of how the calculus can be used to calculate unknown probabilities in this way. If we know or can derive the probabilities on the right, we can calculate  $P(A/B)$ :

$$P(A/B) = \frac{P(A) \times P(B/A)}{[P(A) \times P(B/A)] + [P(\neg A) \times P(B/\neg A)]}$$

In questions of probability a great deal hangs on how we come to 'know' or postulate the probabilities that we use to calculate the unknown probabilities. This issue is central to the explanation of the fine-tuning (Colyvan, Garfield, and Priest *forthcoming*).

### *6.2.1 The relation between the calculus and interpretations of probability*

The current orthodoxy is the Kolmogorov axiomatization.<sup>79</sup> It is important to distinguish the 'calculus' from the 'interpretation' of probability. The calculus can be used to specify probabilities. But when we make probabilistic claims, what do these claims mean? The interpretation of probability is not straightforward. There are several interpretations, and perhaps even more than one type of probability (Carnap 1950). Not all of these interpretations conform equally well to the current orthodox calculus. For

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<sup>78</sup> If the probability space is comprised of an infinite set of mutually exclusive and exhaustive events, then the probabilities of all events (without the employment of infinitesimals) may sum to more than 1. Alternatively, (again without infinitesimals) if the probability of all events is limited to a sum of 1, then some events will have a probability of 0.

<sup>79</sup> For other ways of formalizing the notion of probability, see (Hájek 2001), (Roepke and Leblanc 1999).

example, when the calculus is applied using the propensity interpretation it is difficult to make sense of inverse probabilities. In this interpretation effects must be understood as *having propensities* to have been produced by various different causes (this is known as Humphreys' Paradox (Humphreys 1985)). But we do not normally think of the cause-effect relation in this way. Normally effects either were or were not caused by specific causes. Some people are uncomfortable with this and have been led to question whether such situations are probabilistic (Percival 2000) 368. This issue will be central when I consider the impact of indeterminism on explanation.

Conformity to the calculus is the test of whether an interpretation of probability is 'admissible' (Salmon et al. 1992) 74. But not all agree that the calculus should be the arbiter. When considering the possibility that the laws of this universe may have been set 'probabilistically', Leslie suggests that if probability theory cannot accommodate assigning probabilities to events that could only happen once, then probability theory, not probabilistic physics, should be revised (Leslie 1989) 112. The tension between the concept of probability and the calculus is illustrated by the choice of axioms. For example, the Kolmogorov axiomatization assumes that absolute probability is the primitive term of probability. But other formal mathematical structures, for example, the Rényi-Popper definition (Roeper and Leblanc 1999) do not take absolute probabilities as primitive. Alan Hájek proposes that the primitive of probability should be the conditional probability  $P(A/B)$  (Hájek 2003). This would require a reformulation of the axioms. So while today many people maintain that interpretations of probability must conform to the calculus (based on the Kolmogorov axiomatization) to be admissible interpretations, we should remember that this is open to challenge.<sup>80</sup>

### **6.3 The interpretations of probability**

In this section I explore some major attempts to clarify the concept of probability. Some authors attempt to use only one interpretation, while others use more than one. In this analysis I am not necessarily seeking one 'true' meaning of probability, as there may be

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<sup>80</sup> For a review of non-Kolmogorovian theories of probability see (Hájek and Hall 2002) 166.

more than one meaningful and useful interpretation. However, in this thesis I characterise indeterminism as probabilistic. I take this to imply that probabilities exist independently of our minds. Of the current interpretations, the propensity interpretation is the most appropriate characterisation of these mind independent probabilities.

### *6.3.1 Classical*

Pierre Laplace defined the classical (or Laplacean) interpretation of probability (Laplace 1825). This interpretation is well suited to the clearly defined situations associated with games of chance. Under this interpretation, the probability of an outcome is defined as 'the ratio of favourable cases to the number of equally possible cases' (Salmon et al. 1992) 74. So the probability of drawing the Five of Clubs from a well-shuffled normal deck of cards is  $1/52$ . In this case the 'favourable case' is drawing the Five of Clubs and the number of 'equally possible cases' is the number of cards in a normal deck. While this interpretation has the benefit of being clearly defined, it has problems. The first problem relates (in the example above) to the phrase 'well-shuffled', and to the concept of 'equal possibility' in the definition. The phrase 'equal possibility' is essentially a claim about equal probability and so the definition of probability contains in it the very thing being defined, and this circularity is not acceptable.

Laplace was aware of this problem and justified the concept of equi-probability with the 'principle of indifference'.<sup>81</sup> This principle asserts that two outcomes should be considered equally probable if 'we have no reason to prefer one to the other' (Salmon et al. 1992) 74. This principle is questionable and highlights the distinction between the ontic and the epistemic. There is no ground to assume that just because we have no reason to 'prefer one to the other' that there is no difference in the ontic probabilities of these events.

Even if we accept this principle, there is another problem. The classical interpretation is vulnerable to Bertrand's Paradox (Kyburg 1970) 36. The same probability space can be

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<sup>81</sup> The principle is also known as the 'principle of insufficient reason' (Resnik 1987) 65.

measured in various ways and the choice of measurement yields contradictory probabilities for the same event. This problem would be solved if there were an obviously correct way to measure the space but in many cases there is no obviously correct measurement. The classical interpretation is also purely theoretical. In this interpretation the probability space is divided into classes of events and the probability is calculated by counting these classes. This calculation of probability is independent of empirical data. Thus although the probability is well-defined, the classical probability of an event can neither be confirmed nor refuted by the outcome of an actual event.<sup>82</sup> This makes classical probability somewhat removed from the actual world of events.

### *6.3.2 Relative frequency*

An interpretation with much stronger links to the actual world is the frequency interpretation. While the classical approach counts *classes*, the frequency approach counts *members* of classes, and this makes the latter approach more objective. The frequency interpretation has a long history. Aristotle defined the probable as that which usually happens (or the 'likely' as that which happens for the most part) (Aristotle 1989) 102. There are several versions of the frequency interpretation, but they all have as their starting point actual events in the world.

The actual occurrences of events are counted and compared to the number of members in the appropriate 'reference class'. A simple example is the tossing of a coin. The number of 'heads' can be counted and compared to the number of members in the reference class, 'coin tosses'. Tosses of a coin can be characterized as 'statistical phenomena'. In a frequency interpretation, such phenomena involve a well-defined reference class (coin tosses), but importantly there is variation in that reference class, (the coin doesn't always land heads). However the 'statistical' nature of the phenomena may be epistemic rather than ontic. Phenomena may appear to be statistical due to our limited capacity to understand, manipulate or control the situation in which these events

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<sup>82</sup> However a theoretical probability of 0 or 1 can be contradicted by the outcome of an actual event.

occur.<sup>83</sup> The events may appear statistical because we do not have the capacity to specify the reference class in such a way as to avoid variance. If this is the case, we are not dealing with ontically statistical phenomena but with epistemically statistical phenomena. This is epistemic probability not ontic probability. But I assume for the purposes of this thesis that there is ontic probability. This form of probability involves 'irreducibly statistical phenomena' and in this case no amount of manipulation of the situation or re-specification of the reference class removes the variance. This is the realm of indeterminism.

The simplest frequency interpretation is the strict relative frequency interpretation. Probability is defined simply as the relative frequency of a specified event in some population of events. This interpretation counts members in classes. The attribute class defines the features of a specified event and the reference class is the population of events under consideration. Thus the strict frequency probability is simply the fraction obtained from using the number of events in the attribute class as the numerator and the number of events in the reference class as the denominator. The great advantage of this approach is that it is very well-defined. However one of the disadvantages of the strict frequency approach is that as the population in the reference class increases over a number of trials the strict relative frequency probability also changes. Intuitively probability is not that fluid. In an attempt to avoid this ambiguous fluidity a move was made to a more hypothetical approach. This is the limiting frequency interpretation. In this version the probability is the value of the above fraction in the hypothetical situation in which there are an infinite number of trials. Notice now that although the frequency approach promised a more concrete interpretation of probability the move to

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<sup>83</sup> It may be possible to change the probability by manipulating the situation. This manipulation would, in effect, create a new reference class. Perhaps in one reference class (where the coin is tossed 'naturally') the coin tends to land heads 50% of the time. However, it may be possible to change the number of occurrence of heads by manipulating the situation and thus redefining the reference class. Perhaps if the reference class is only tosses in which the coin is tossed in a very precise way (e.g., on a machine with a specific action that generates a toss with limited revolutions, and with the coin always beginning with heads uppermost), then the coin may land heads 90% of the time. Further, it may be possible to specify a reference class in which the toss becomes invariant, meaning that the coin lands heads 100% of the time. If it is possible to specify the reference class such that the outcome is invariant the phenomena are no longer 'statistical'.

hypothetical limiting frequencies seems to have lost the 'reality' that was attractive about this approach. And even with this compromise there are problems and limitations.

Two of the most serious problems relate to the *specification* and *existence* of the limiting frequency. In any real situation, we only have access to a finite sample of events with which to estimate the limiting frequency. But it is possible that the finite sample (however large) is not representative of the frequency in the total infinite population. This has led some to argue that a relative frequency determined using any finite sample of an infinite sequence is in fact irrelevant to the relative frequency of the infinite sequence itself and further it is possible that no such limiting relative frequency even exists (Salmon et al. 1992) 78-9. But, for our purposes, the most significant limitation facing the relative frequency interpretation is that, because relative frequency is defined in terms of members of *classes* of events and not *specific* events, individual events do not have probabilities. This is known as the *problem of the single case*. Thus the universe taken as an isolated event does not have a probability.

### 6.3.3 *Propensity*

The 'problem of the single case' led to the propensity interpretation of probability.<sup>84</sup> Although the frequency and propensity approaches share the concept of statistical phenomena, the propensity approach can be considered as shifting the focus from the *events* to the *circumstances* of the event or the 'chance set up'. A chance set up may be a simple coin toss, or it may be a scientific experiment related to quantum decay. The probability in the propensity approach is defined by the chance set up. Single events produced by this chance set up have probabilities. Propensity is presented as 'a probabilistic causal tendency' of an experimental set up (Salmon et al. 1992) 80 or, to quote Philip Percival, the frequencies 'exhibited in statistical phenomena are the manifestation of some dispositional physical property of the experiment, set up, or objects experimented upon' (Percival 2000) 367.

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<sup>84</sup> Propensity interpretations can be classified into *long run* and *single case* theories (Gillies 2000) 822. I will not engage with the detail of this distinction. I will be concerned with the single case theories.

But there is a problem with the propensity interpretation that relates to conditional probability and the use of Bayes' Theorem. If we know the conditional probability of some evidence given a certain hypothesis, the application of Bayes' Theorem allows us to calculate the inverse probability, or the conditional probability of the hypothesis given the evidence. But if we interpret probability as a propensity then we must interpret the probability of the hypothesis given the evidence as some form of *tendency* to be true. This oddity is referred to as *Humphreys' Paradox* (Humphreys 1985). Intuitively, we feel that hypotheses are either true or not true. Consider the case of atomic decay. A Thorium atom has a probability that it will decay. Take the case in which it decays. With Bayes' Theorem we can calculate the probability that *this* 'decayed' atom was an atom of Thorium. Intuitively this is odd. We are uncomfortable with the idea that the atom had a propensity to be Thorium.<sup>85</sup> Because there is no way to make sense of the inverse probabilities here, the propensity interpretation of probability does not conform to the calculus. For many, this is a serious drawback (Salmon et al. 1992) 74-81.

#### *6.3.4 Subjective degrees of belief*

Another approach to probability is to interpret it as a subjective degree of belief. This interpretation is known as personal or psychological probability and the adherents of this approach are often referred to as Bayesians, due to the central role of conditionalization using Bayes' Theorem. Under this approach probabilities are considered to be degrees of rational partial belief or 'degrees of conviction' (Salmon et al. 1992) 82. One risk with this approach is that the probabilities may sum to more than 1, and thereby not conform to the calculus. However, the 'coherence condition' avoids this by requiring that the probability of coherent beliefs sum to 1. Critics of this approach argue that the mere requirement of coherence is not strict enough to be epistemically responsible, and that it allows for too much subjectivity in the determination of probabilities.

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<sup>85</sup> Adapted from an example used by Dowe (personal communication). A similar example using frisbee production can be found in (Salmon et al. 1992) 80.

To avoid the charge of subjective prior probabilities, proponents of this position rely on conditionalization. As probabilities are repeatedly conditionalized with new evidence, they argue that the subjectivity in the prior probabilities is washed out. Imagine watching the repeated tossing of a coin that you originally considered to be fair. If the coin consistently lands heads, then your original probability estimation of heads may be washed out. One limitation for this technique relates to isolated events. If the evidence is restricted to an isolated event, the process of 'washing out' could not remove the subjectivity of the priors. For example, if the universe is considered an isolated event (given we have no evidence or experience of other universes), then it is difficult to defend estimations of the prior probability of this universe from charges of subjectivity.

### 6.3.5 *Logical*

The final interpretation that I consider is the logical interpretation of probability.<sup>86</sup> Rudolf Carnap has done most to provide a formal structure for this interpretation of probability. (Carnap 1950) He distinguished two forms of probability, one based on logical relations (probability<sub>1</sub>) and another based on frequencies (probability<sub>2</sub>). But it is his work on logical or probability, that interests us here. Logical probability (also known as inductive probability or 'degree of confirmation') was developed as a formal inductive logic to match formal deductive logic. In deductive logic if  $p$  entails  $q$ , then if  $p$  is true,  $q$  is true. This entailment relation can be considered 'probabilistically' if we consider that  $p$  'probabilifies'  $q$  with a degree of 'one'.<sup>87</sup> Similarly in inductive logic we can consider the same 'probabilification' relation between  $p$  and  $q$ , but in this case  $p$  'probabilifies'  $q$  with a value of less than one. This probabilistic entailment has also been called 'partial entailment' (Salmon et al. 1992) 85. Here logical probability is

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<sup>86</sup> Logical probability is the foundation of confirmation theory (Swinburne 1973). Swinburne uses this theory in his argument that the fine-tuning of the universe is evidence for the existence of God (Swinburne 1991). I examine confirmation theory and Swinburne's argument later in the thesis. Note that Swinburne has used the term 'epistemic probability' (Swinburne 1973). But his usage is different to mine.

<sup>87</sup> However some would disagree with this characterisation due to the 'subtle difference' between logical necessity, and a logical probability of 1 (Fetzer 1970) 479.

essentially a conditional probability relation between propositions  $p$  and  $q$ , such that  $p$  'probabilifies'  $q$ , as a form of logical consequence.

Like the other forms of probability, this interpretation encounters problems. The central problem is how the prior probabilities of the hypotheses are determined. Here there are interesting parallels with the classical interpretation. As noted by Hájek the logical interpretation retains the idea of the classical interpretation that probabilities can be determined *a priori* by consideration of the possibility space. But while the classical interpretation assumes the principle of indifference the logical interpretation does not. In the logical interpretation, although different possibilities may be given equal prior probability, different possibilities can also be given different prior probabilities (Hájek and Hall 2002) 159. However, the problem is how to justify the prior probabilities regardless of whether they are equal or not. If in the logical interpretation all possibilities are given equal prior probability, then we face the same problem faced in the classical interpretation and the same 'solution' can be used here, namely, the principle of indifference. But, the same limitations of the principle are faced here also (Percival 2000) 365.

#### 6.4 Probability: objective or subjective - ontic or epistemic?

Now I propose to approach probability in a different way. I propose to consider how probability relates to the world. It seems that there are fundamentally two ways that probability could relate to the world. It is either in *the world* or in *the descriptions* of the world. Just as we can ask whether laws of nature, and mathematics are ontic or epistemic, so too we can ask whether probability is ontic or epistemic.

Traditionally interpretations of probability are separated into two broad categories, objective and subjective. Objective probability is thought of as in the world, independent of the beliefs of those who talk of probability, while subjective probability is in some way dependent on the beliefs of those people. Frequency interpretations and propensity interpretations are traditionally presented as objective. The probabilities here are considered to be in the world. At the other end of the spectrum is the probability associated with subjective degrees of belief. This form of probability is clearly

considered to be an aspect of our understanding of the world.

However this leaves the logical and the classical interpretations of probability. Although these have been traditionally understood as objective, classifying either of these as objective or subjective is problematic. Neither of them seems unambiguously objective or subjective. They are not objective in the sense that the propensity interpretation is presented as objective; they do not seem to be 'in the world' as propensities are claimed to be. But neither are they subjective in the sense in which degrees of belief are presented. Conventionally logical and classical interpretations are considered as objective interpretations, in that they are based on 'logical or mathematical structures' (Resnik 1987) 61. However the word *objective* is ambiguous here. The objective nature of logical and mathematical structures can be called into question.

Rather than classifying the classical and logical interpretations as either objective or subjective I propose different terminology. I will use the distinction between the ontic and epistemic. We can ask the question: is probability ontic or epistemic, or both? This turns on the distinction between the characteristics of the description and the characteristics of that described. Is probability only a characteristic of the description, or is it also a characteristic of that described? If probability is only a characteristic of the description and not a characteristic of that described, then classical and logical probability can be defined as epistemic. In order for them to be ontic, the classical and logical probabilistic structures would need to be ontic structures; structures that exist independently of our minds. So, I contend, there are two distinct notions of probability, epistemic and ontic. Classical, logical, and subjective degrees of belief can be considered epistemic because they are characteristics of the description of the world. Propensity and frequency can be considered ontic because they are characteristics of that described.

It could be argued that the frequency interpretation is actually epistemic probability as well. Perhaps the 'statistical phenomena' on which the probabilities are based are only epistemically indeterministic but ontically deterministic. Before the advent of quantum physics many people considered that the world was deterministic. If determinism were true, then there would be only two values of ontic probability for physical events, 0

or 1. Given the laws and initial conditions of the universe, all the events that occurred in a deterministic world would be physically necessary and all the events that did not occur would be physically impossible. Thus their physical probability would be 0 or 1. This is to be distinguished from the epistemic probability. Even in a deterministic world the epistemic probabilities of events can range from 0 to 1. This is because the epistemic agents may base their probability estimations on less than the total situation (Swinburne 1973) 12.<sup>88</sup>

With the advent of quantum theory, it is believed that the world is at least in part indeterministic. This means that the evolution of physical systems is contingent, in that they admit the existence of ontic possibility. If these systems admit the existence of ontic *possibility*, then they admit the existence of ontic *probability*. So there are two types of probability that we must keep in mind. Ontic probability is related to indeterminism in the world, and epistemic probability is related to our knowledge of the world.

## 6.5 Probability space

### 6.5.1 *The nature of the probability space*

The concept of 'probability space' is a convenient way of understanding the probabilities of events in a given situation. The whole probability space comprises all the events in a certain situation. Each distinct event is defined as a point in the probability space. Each event has a certain probability of occurring and so each point in the probability space has a probability value.<sup>89</sup> The games of chance that gave rise to the probability calculus, involving rolls of dice and hands of cards are fundamentally simple. These situations generally involve well-defined, finite, and discontinuous probability spaces, often comprising mutually exclusive and exhaustive events. For example, when we roll a die, there are six possible outcomes and each outcome is

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<sup>88</sup> A further argument could be made to claim that frequencies are subjective, because *we define* the members of the reference class. Against this, it would need to be demonstrated that the definition was 'objective', or a characteristic of the world, rather than just a characteristic of the description of the world.

<sup>89</sup> Impossible events are represented in a probability space by points with a probability value of 0.

exclusive; we cannot roll a 3 and roll a 4 on the same roll with the same die. Not all situations are that simple. When considering other probability spaces, we must consider the nature of the space. The first question is whether the space is finite or infinite in the sense of being bounded or unbounded. Some probability spaces are unbounded and thus infinite and these spaces face the normalization problem when we try to quantify the probabilities of events in these spaces. The probability of any event or finite range of events in an infinite (unbounded) probability space is zero, (unless infinitesimals are employed). Finite (bounded) probability spaces are easier to manage but are arguably less common in the real world.

The next issue is whether the probability space is continuous or discontinuous. In a continuous probability space, say, the space defined by the co-ordinates between 2 and 3 on the x and y axis, there is an infinite number of points and thus any one point (ignoring infinitesimals) has a probability of 0. But ignore this complication for now. Let us assume that in a continuous probability space all events in the space have some positive probability of occurring (and assume that there is more than one event in the space). So every point in the space defined by the co-ordinates between 2 and 3 on the x and y axis has some probability greater than 0 and less than 1. However, if the probability space is discontinuous, some points have a probability of 0, and thus are impossible. Another way to illustrate a discontinuous space is to consider the roll of a die. There is no probability that the die will land  $4\frac{1}{2}$ . This is impossible and so has 0 probability.

The final concept to consider at this stage is the probability distribution of the probability space. I think of this as the probabilistic topography of the space. All the possible events in a probability space have some non-zero probability. But what are the probabilities of these different events? One solution is to assume the 'principle of indifference'. This is equivalent to a topographic plane. But the probability of each possibility may not be equal. This is equivalent to a more complex topography, such as a mountain range. However, while bearing in mind that the principle of indifference is an assumption, it is useful to employ it to simplify my analysis. We will eventually consider the situations in which every event is not equally probable. But, for now, let us consider a probability space that is mutually exclusive, exhaustive and each member of

the probability space has the same probability of occurring. In other words let us consider a finite probability space, comprising discontinuous equi-probable events.

### 6.5.2 Demonstrative and non-demonstrative partitions of the probability space

In a non-demonstrative partition every distinct possibility is considered separately.<sup>90</sup> So each possibility has its own cell in the partitioned space. On the other hand, in a demonstrative partition, every distinct possibility is not necessarily considered separately. There may be more than one distinct possibility in any one cell in the demonstratively partitioned space. Consider a simple probability space. Each distinct possibility is represented by a position on the x-axis and the probability of each possibility is represented on the y-axis.<sup>91</sup> For simplicity I use an equi-probable situation, so each possibility has the same probability, as in Figure 6:1.

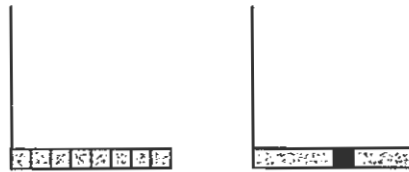


Figure 6:1 demonstrative and non-demonstrative partitions of equi-probable space.

In the left hand diagram the probability space is partitioned non-demonstratively; each possibility is considered separately. The right hand diagram illustrates a demonstrative partition. In this demonstrative partition one possibility is distinguished from the other possibilities, so in effect there are just two possibilities: in this case 'black' and 'not black'. Notice that some feature of the possibility (namely its blackness) is the basis of the partition.

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<sup>90</sup> In a continuous probability space, partitions separating individual points would be unmanageable, as this would lead to an infinite number of partitions, so partitions based on finite ranges can be used.

<sup>91</sup> For the purposes of this illustration, I will consider a finite set of discrete positions on the x-axis, and ignore the problems associated with the infinite set of points on a line.

When we considered partitioning possibility space, the choice between non-demonstrative and demonstrative partitioning led to the issue of subjective and objective partitions. To me, non-demonstrative partitioning generally seems objective. However demonstrative partitioning is not obviously objective. I take the choice to partition the space demonstratively to be justified by subjective reasons. Recall the choice to partition the possibility space of the die roll based on the partition  $\{3, \neg 3\}$  because \$1000 was bet on the die landing showing 3. This same justification can be used to partition the probability space here. But, this is not an objective justification for the partition; it is subjective. It may be possible to present a justification for an objective demonstrative partition, but in the absence of such a justification I assume the demonstrative partition to be subjective.

### 6.5.3 Determining the probability of a particular partition

The probability of an event in a non-demonstrative partitioned probability space (assuming equi-probability) is straightforward. It is simply the fraction 'one over the total number of possibilities'. If there are 10 possibilities, then the probability of any one of them is  $1/10$ , and if there are 100 possibilities then it is  $1/100$ . The calculation of a probability in a demonstratively partitioned probability space is not so simple. This is because the space is effectively considered as only two partitions ( $A, \neg A$ ). If we used the method that we applied in non-demonstratively partitioned probability space, then the resultant probability would be  $1/2$ . This is clearly an error. To understand the probability in a demonstrative partition, we must first convert the demonstrative partition into the equivalent non-demonstrative partition, and then convert it back, Figure 6:2. This process captures the true probabilities associated with demonstrative partitions.

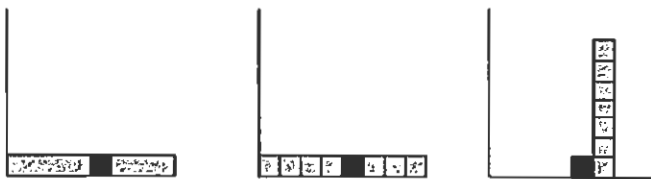


Figure 6:2 calculating the probability of a demonstrative partition

## 6.6 Improbability, isoprobability, expectation and surprise

### 6.6.1 Absolute and relative improbability

What does it mean for something to be *improbable*? Here I distinguish two senses of improbability: absolute improbability and relative improbability. I take absolute improbability to identify a single numerical value. If an event has a probability lower than this value it is improbable. If an event has a probability higher than this value it is not improbable. Conventionally anything that has a probability of less than a half is taken to be improbable (Dembski 1998) 198. So  $1/2$  would be a potential value of absolute improbability. Alternatively, I could choose some other value, say  $1/10,000$ , but what would make  $1/10,000$  more worthy than  $1/100,000$ ? Any value other than  $1/2$  seems arbitrary. It seems that  $1/2$  is the best option for the value to define absolute improbability. However, I suggest that the notion of absolute improbability is of little significance. Consider wandering through town with no specific plan, walking into a bookshop and buying a book. I imagine that returning home with a book has a probability of less than  $1/2$ , but it seems odd to refer to it as improbable. It seems that most events that occur would have a probability of less than  $1/2$ . Therefore, it seems that the notion of absolute improbability can be improved.

There is another way to give meaningful sense to the notion of improbability. To do this 'improbable' must be accepted as a *relative* term. To say that something is improbable is only meaningful if the event in question is *improbable* relative to some other event that is *probable*. This in some measure explains the absolute improbability value of  $1/2$ . If there are only two options and one option has a probability of less than  $1/2$ , the other must have a probability of more than  $1/2$ . But in this case, it is in effect the *relative improbability* that is doing the work here *not the value of  $1/2$* . This justifies the notion of improbability in the case of only two possibilities, but this notion of improbability loses credibility when considering more than two possibilities. Consider three possibilities, one with a probability of  $4/10$  and the other two with probabilities of  $3/10$ . The first option is improbable using the 'less than  $1/2$ ' convention, but probable in comparison to the other options. This illustrates that it is not meaningful to consider events as improbable in an absolute sense. I contend they must always be considered relative

to other events. The significant point is that if all events in a given situation have the same probability, then there is no meaningful sense in which one event is improbable (or probable) relative to any other event. The notion of improbability is based on the concept of *differential probability*. This is similar to the existence of differential *size*. Something is 'small' only in relation to other 'large' things.

#### 6.6.2 Differential probability

Differential probability requires outcomes to have *different probabilities*, where one outcome is more probable than another outcome. In my discussion I am considering events of equal probability. Considering differential probabilities when I have specified the equi-probability of possibilities seems contradictory. However, there is the potential for differential probabilities in an equi-probable situation. It is possible due to demonstrative partitioning, where the space is partitioned in the form  $\{A, \neg A\}$ . This partition creates the potential that 'A' may be *improbable* in comparison to ' $\neg A$ '. Consider the equi-probable members of a probability space (A, B, C, D, E, F, G, H, I, J). Using the demonstrative partition,  $\{A, \neg A\}$ , 'A' has a probability of 1/10 while ' $\neg A$ ', has the probability 9/10. Thus 'A' is improbable compared to ' $\neg A$ '. It is important to understand that the improbability of A is *dependent* on the demonstrative partition. Without it there can be no differential probability in equi-probable situations. This may seem obvious but it is an important point, the implications of which seem to have been overlooked. For example, many people consider it improbable to win a lottery. However, the notion of the win being improbable is only justified if we employ the demonstrative partition {we win, we don't win}. If the probability space is partitioned non-demonstratively {ticket 1 wins, ticket 2 wins, ticket 3 wins, ...}, then no ticket winning is any more or less probable than any other ticket winning. So it is not improbable that any particular ticket wins; each ticket simply has the same probability of winning. Differential probability and hence improbability is not compatible with equi-probable possibilities when those possibilities are partitioned non-demonstratively. To describe this I use the term 'isoprobable'.

### 6.6.3 Isoprobability

Isoprobability relates to situations in which all possible outcomes are considered to be equi-probable, and the probability space is partitioned non-demonstratively. I argue that non-demonstratively partitioned, equi-probable probability spaces do not allow for differential probability and thus the notion of improbability is not appropriate.

Consider a simple example of a non-demonstratively partitioned equi-probable space. Consider selecting a ball from an urn containing a large number of indistinguishable red balls, each of these balls having equal probability of being selected. What is the probability of selecting a red ball? Assume that we succeed in selecting a ball, so the probability is 1. But what is the probability of selecting a specific red ball? There is an important distinction here between 'some' red ball and 'this' red ball. The probability of getting 'some' red ball is 1. The probability of getting 'this' red ball is not 1. But I argue that it is a mistake to say that it is improbable.

The probability of selecting a specific ball depends on the number of balls in the urn. If there are 10 red balls, then the probability of selecting a specific ball is  $1/10$ . If there are 100 red balls, then the probability is  $1/100$ . This is what I call equi-probable non-demonstrative probability. This probability is dependent on the total number of equi-probable outcomes possible in the given situation. The intuitive response in this situation is to say that it is *improbable* to select any specific ball. But I argue this is a mistake.

Consider the notions of improbability and differential probability. I hold that improbability is a relative notion. I only consider events to be improbable because I compare them to other events that are probable. Improbability presupposes differential probability. Without differential probability there can be no *improbable* events or, for that matter, *probable* events. For there to be improbable events there must be the potential for probable events. To understand this, return to our urn of indistinguishable red balls. If there are 100 balls in the urn, then we may say that selecting any specific

ball is improbable. But why say this? It may be because  $1/100$  is a small number.<sup>92</sup> But 'small' is also a relative term.  $1/100$  is small relative to  $1/10$  but it is big relative to  $1/1000$ . This impacts directly on the notion of improbability. Consider that drawing a specific ball has a probability of  $1/100$ . Clearly it is *improbable* in comparison to an event with a probability of  $1/10$ . But equally clearly it is *probable* in comparison to an event with a probability of  $1/1000$ . So there is a sense in which it is improbable (or probable) but only in comparison to events of different probability.

But we are *not* comparing this event with events with the *different* probabilities of  $1/10$  or  $1/1000$ . By definition, there are no balls in the urn with probabilities of  $1/10$  or  $1/1000$  of being drawn. We are comparing this event (the drawing of a specific ball) to other events (the drawing of other specific balls) and all these events have the same probability of  $1/100$ . When we compare  $1/100$  to  $1/100$  there is no sense in which one is smaller or larger than the other. Equivalently, if  $1/100$  and  $1/100$  are probabilities there is no sense in which one is more or less probable than the other. So there is no sense in which the drawing of a specific red ball (relative to drawing another specific red ball) is probable or improbable; it is 'isoprobable'. So in non-demonstratively partitioned, equi-probable situations, situations in which all the outcomes have an equal probability of occurring, there is no meaning to the term 'improbable'.

The only reasonable way to think of events in equi-probable situations as 'improbable' is by imposing a demonstrative partition. So far in our urn example we have been using a non-demonstrative partition, where every ball is considered individually (A, B, C, ...). So when comparing events we were comparing events of equal probability. Hence the probability of 'this ball' was  $1/100$ , the probability of the next ball was  $1/100$ , and the next ..., and so on. But a demonstrative partition is different. This is the partition 'this ball', 'not this ball'  $\{A, \neg A\}$ . Now there is a reasonable sense of improbability. The probability of 'this ball' is  $1/100$ , and the probability of 'not this ball' is  $99/100$ . So using a demonstrative partition, selecting 'this ball' is clearly improbable. But it should

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<sup>92</sup> Or using the notion of absolute improbability, it may be because  $1/100$  is less than  $1/2$ .

be noted that the improbability is derived from the demonstrative partition. Without the demonstrative partition there is no sense of improbability in equi-probable probability space.

It is possible to have *improbable* events in equi-probable situations, but only if we use a *demonstrative* partition. Now it should be clear why I began this illustration with a set of *indistinguishable* red balls. If we wish to use a demonstrative partition, we must have a justification. What justification will we use? *The balls are indistinguishable*. Why would we choose to partition the space by selecting any specific ball? We can arbitrarily choose a ball and define it as 'this ball' then partition the space demonstratively in relation to that ball. Then the selection of specifically 'this ball' (as opposed to the selection of 'not this ball') would be improbable. We would have differential probability. But why would we do that? There must be a *reason* to partition the probability space demonstratively. This reason may be objective or subjective. If the justification of the partition is objective, then the objective demonstrative partition generates an objective improbability. However, if the justification for the demonstrative partition is subjective, then the improbability generated is equally subjective. 'This ball' might have significance. But without an *objectively significant* difference between 'this ball' and 'not this ball' there is no objective justification for partitioning the probability space demonstratively, and therefore no objective differential probability, and so no objective improbability, only *isoprobability*.

A demonstrative partition of equi-probable probability space can result in a meaningful sense of differential probability and hence a meaningful sense of improbability; 'A' can be considered improbable while ' $\neg A$ ' can be considered probable. But there must be an objective reason to partition the space demonstratively. One good reason *not* to partition the space demonstratively is merely in order to *create* the improbability! Demonstrative partition must be independently justifiable.

Consider all possible outcomes of a series of 10 coin tosses, where the series as a whole is considered as the 'event'. Take the outcome, HTTHHHTTHT, and call it 'A' and call the other outcomes ' $\neg A$ '. Under this demonstrative partition the outcome 'A' is very improbable and the outcome ' $\neg A$ ' is very probable. But this differential probability

has no objective significance. There is no objective justification for this demonstrative partition, and so any differential probability that results from the partition is not objective. This is not to say that there is no subjective justification and thus subjective improbability, but subjective improbability is not objective improbability. Without the objective justification for the demonstrative partition there is no objective differential probability. All outcomes are *equally* probable.

The justification of a demonstrative partition is central to the fine-tuning debate. If any demonstrative partition of possible universes can be justified on objective grounds, then there is real potential for universes in such a partition to be improbable. But without an objective justification for the demonstrative partition, the only *objective* partition is non-demonstrative. There is of course, the possibility of a subjectively justified demonstrative partition but this will not provide any argumentative force against those who dispute the justification. So assuming the probability space is uniform, and applying a non-demonstrative partition, no universe is improbable.<sup>93</sup> All universes are isoprobable. Finally, we should be wary of one particular demonstrative partition, the partition {'this A', 'not this A'}, where 'this A' is the one we observe. There must be an objective reason that 'this A' is different to 'not this A' and the mere 'observational selection' of 'this A' is not enough to justify a demonstrative partition.<sup>94</sup>

#### *6.6.4 Probability, expectation, improbability and surprise*

I take the following conditional to be uncontroversial. If we accept that a certain event has an ontic probability of occurring, then we expect that probability to be reflected in the frequency of the occurrence of that event. For example, if we accept that a coin has an ontic probability of 1/2 of landing heads then, in a long series of tosses, we expect the coin to land heads about 1/2 of the time. If the coin does not land heads about 1/2 of the time, then we think that our belief about the ontic probability of the coin landing heads is

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<sup>93</sup> The assumption that each universe is equally probable is made here for the purposes of illustration only. I do not make this assumption in relation to the ontic probability space of universes.

<sup>94</sup> This is the point made by Scriven (Scriven 1966) 129.

erroneous. In the terminology used in this thesis, our belief about the ontic probability of an event is the event's epistemic probability.

Applying this idea, the relation between probability and expectation is straightforward. We simply expect the occurrence of events to conform to their epistemic probability. But this idea is also relevant to the relation between improbability and surprise. When actual events do not conform to their epistemic probability this is unexpected, or surprising. Here it is important to note that there can be degrees of conformity. There is an inverse relation between conformity and surprise. Thus the less the events conform to their epistemic probability the more unexpected or surprising the events. Note that there is a direct link between probability and expectation, but there is no direct link between improbability and surprise.

However this idea shows how probability in general relates to surprise. Surprising events are events that do not conform to their epistemic probability. Surprise can be generated by events occurring either too frequently or too rarely. Events that we *do not expect to occur regularly* (events of low epistemic probability) can be surprising if they *do occur regularly*. And events that we *do expect to occur regularly* (events of high epistemic probability) can also be surprising if they *do not occur regularly*. Notice also that this idea has important implications for isolated events. If an event has happened once, and we have no further information about other possible occurrences of the event, then that event conforms to every possible epistemic probability, other than 0. In other words, isolated events are surprising only if we believe they are impossible.

#### *6.6.5 Isoprobability and surprise*

Now consider the relation between isoprobability and surprise. Retuning to our urn, the probability of drawing a specific ball is  $1/100$ . But given the isoprobability argument above, it is inappropriate to consider the drawing of a specific ball *improbable*, since it is no more nor less probable than drawing any other specific ball. So there is no meaningful sense of improbability when dealing with non-demonstratively partitioned equi-probable probability space. However, there is a meaningful sense of expectation and surprise. We expect the empirical frequency of events to conform to their epistemic

probability, and if they do not, (taking into account degrees of conformity) we are surprised.

Now in our urn of 100 indistinguishable balls, let us mark one ball to distinguish it from the rest. In a sufficiently long series of random draws, say 1,000,000, if this marked ball is selected on average substantially more often (or indeed less often) than once in every 100 draws, *this* would be surprising, but the selection of the marked ball in any *single* draw would not be surprising.<sup>95</sup> Note this analysis implies that it is not possible for an event in isolation to be surprising. Surprise is due to an event not conforming to its epistemic probability. The only way an *isolated* event cannot conform to its epistemic probability is if that probability is 0. The only way an isolated event can be surprising is if we believe it is impossible. This may not reflect common intuition with reference to surprise, but it is the implication of the foregoing analysis.

Return to the series of 10 tosses of a coin, HTTHHHTTHT. I argued above that this series was not improbable, because it was *as probable* and *as improbable* as any other series of 10 tosses. I argued it is not improbable, but rather, it is isoprobable. Any single event (here the 10 tosses are considered a single event) in an equi-probable situation cannot be improbable. This is not to say that it does not have a probability; just that it is inappropriate to call it improbable. And it is inappropriate simply because all the events are equally probable. But, if we were to see the *same* event, i.e., the same series, HTTHHHTTHT, exactly repeated (i.e., another event), that would be surprising, because the event does not conform to its epistemic probability.<sup>96</sup>

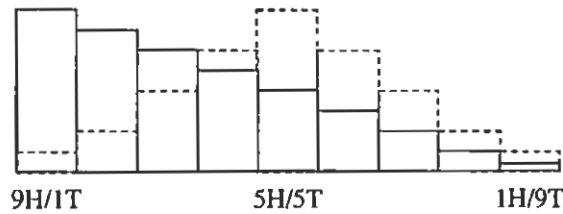
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<sup>95</sup> David Coady (pers. comm.) claims that if the marked ball was drawn on the first draw, *this would be* surprising. But on my argument, we *should not be* surprised. While James Chase (pers. comm.) agrees with David he points out that this surprise may be due to the first draw being 'significant'. Thus I can ask: is the first draw subjectively significant or objectively significant? Incidentally Dembski may wish to argue that the drawing of the marked ball on the first draw was a specified event of small probability and thus chance can be eliminated (Dembski 1998). For further discussion see chapter 10 of this thesis.

<sup>96</sup> On this approach, if we *redefine* the two events as one event this removes the surprise. This is a limitation of this approach and highlights the problem of defining the boundaries of an event.

### *Probability Space*

We can now generalise this example to situations that do not comprise equi-probable events. Consider multiple trials of an event,  $T$ , where the event is 10 tosses of a coin. Consider the frequency of different outcomes of this event. Here we consider any sets of tosses with the same number of heads and tails as the same outcome. In other words, we will not differentiate between different orders of heads and tails, only total number of heads and tails. In this situation, there are many different combinations of heads (H) and tails (T) that may occur. But given that we believe the coin to be fair, we assume that the combination of (5H/5T) will be more common than either of the combinations (9H/1T) or (1H/9T). Figure 6:3 represents the expected frequency distribution by the dashed line.



*Figure 6:3 The expected frequency versus the actual frequency*

But now consider the situation that in a long series of actual trials the combinations of (1H/9T) is very common and the combinations of (5H/5T) is less common, as represented by the solid line. We should be surprised, because the actual frequency distribution of events does not conform to the expected frequency distribution.<sup>97</sup>

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<sup>97</sup> The degree of conformity to an expected probability distribution may be related to Hans Reichenbach's 'higher level' probabilities (Fetzer 1970) 478.

## 7 The Probability of the Fine - Tuning

### 7.1 An assumption

The fine-tuning debate is based on the assumption that the universe could be improbable in some meaningful sense. I will consider whether this assumption is reasonable. At the outset, it should be noted that Mellor argues that, when the universe is understood as *everything*, it is simply inappropriate to use probabilistic language with reference to the fine-tuning. He considered three interpretations of probability: frequency, personal and inductive (these are equivalent to what I have called relative frequency, subjective and logical) and argues that none of them provides a foundation for a claim that the universe has a probability of existing, let alone is improbable (Mellor 1973).<sup>98</sup> However for the purposes of this investigation I will assume that there is some meaningful sense in which we can understand the probability of the fine-tuning.

I have explored the concepts of possibility space and probability space. Now I combine these concepts to consider the probability of the fine-tuning. It is important to distinguish the probability of the fine-tuning *per se* from the role of probability in *explaining* the fine-tuning. I will consider the role of probability in explaining the fine-tuning in a subsequent chapter.

### 7.2 Probability and the fine-tuning

#### 7.2.1 The fine-tuning and the standard interpretations of probability

In what sense can we regard the universe as improbable? Let us begin with the five standard interpretations of probability considered above: the classical, logical, relative frequency, propensity, and subjective degrees of belief. Let us consider whether any constitute viable options for interpreting the probability of the fine-tuning.

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<sup>98</sup> Later in this thesis I will consider the possibility that this universe is the product of a quantum vacuum fluctuation. If the quantum vacuum can be considered as an immaterial chance set up, then this may justify consideration of the probability of the fine-tuning using the propensity interpretation.

### *The Probability of the Fine - Tuning*

Subjective probability is the most liberal interpretation of probability. Under this interpretation, probability is understood as 'degrees of belief'. But when we consider the subjective probability of the fine-tuning, we must be careful not to confuse two types of subjective probabilities. Firstly, we can have a degree of belief *that* the parameter values are the ones that the physicists claim they are. So we can assign a subjective probability that measures our *confidence* that this is so based on the evidence. Secondly, even if we are *certain* that the fine-tuned values are the ones we think they are, we can have a subjective belief about the ontic probability of the fine-tuning. Let us discount the first type. We are not interested in how confident we are about the evidence. We are interested in our subjective belief about the ontic probability of the fine-tuning. Clearly it can be either probable or improbable simply by someone holding the appropriate degree of belief with respect to the ontic probability of the fine-tuning. The problem is that people may disagree, and there is no obvious way of determining who is right. One response is the subjective Bayesian approach of 'washing out' the subjective priors by conditionalizing on new evidence. Bayesians argue that although people's subjective assignments of prior probability may disagree, conditionalization on new evidence results in the probabilities converging to an agreed value. But this approach cannot be applied to the fine-tuning. There is only one fine-tuned universe to which we have epistemic access, so no conditionalization on new evidence (in the form of other universes) is possible. If we have epistemic access to other universes, we could consider these as other evidence and we could use this other evidence to 'wash out' the subjectivity of our estimation of the prior probability of *this* fine-tuned universe in order to determine whether the fine-tuning was improbable. But washing out is not an option. So the subjective Bayesian response does not help here.<sup>99</sup> Without it there does not seem

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<sup>99</sup> Swinburne does not explicitly characterise himself as a Bayesian, however, he could be characterised as an 'Objective Bayesian' (see the following footnote). In the main argument of *The Existence of God*, he employs a technique similar to 'washing out the priors' (Swinburne 1991). Swinburne's project in this book is to gather together what he calls good 'C inductive arguments'. He contends that these arguments make their conclusions more probable than they would otherwise be, and that these good 'C inductive arguments' taken together may form a good 'P inductive argument'. A good 'P inductive argument' makes its conclusion 'probable' (Swinburne 1991) 7. Taken as a whole, this process is very similar to the notion of washing out the priors. However, here I am not considering all of Swinburne's arguments for the existence of God. I am considering his argument from the fine-tuning of the universe in isolation.

to be any way to remove the significant subjectivity of degrees of belief. So I contend that this interpretation is not a viable option.

Now consider the relative frequency interpretation. This is the most straightforward interpretation of probability. Under this interpretation probability is calculated using the actual frequency of events. If we have epistemic access to other universes, we could count the number of these universes that had the fine-tuned values and this number, as a fraction of the total number of universes, would give us the probability of the fine-tuning. Indeed one of the responses to the fine-tuning is the postulation of many other universes. But, on pain of circularity, the *postulation* of other universes cannot establish the probability of this universe. So the fact that we only have access to one universe causes problems for this interpretation. Alternatively, we could calculate the probability of this life-allowing universe using actual frequency of observed universes, but (on the strict frequency interpretation) this would make the probability of this universe 1, and this would leave no room for a fine-tuning debate. There is another problem here. The frequency interpretation does not attribute probability to isolated events, only to classes of events. So this universe, as an isolated event, lacks a probability.

What about the propensity interpretation? We can assume, because we have no evidence to the contrary, that the universe is an isolated event. The assumption that this universe is an isolated event led us to reject the previous two interpretations of probability. The propensity interpretation was developed to deal with the single case. Isolated events and single case events can be considered similar if not the same. So this interpretation may be more helpful. But again we face a problem. The propensity interpretation is based on the idea that a single event has an objective probability of occurring in a 'chance set up'. The problem we face relates to the 'chance set up' of the universe. Mellor puts the point well.

A chance process needs a "chance set up" on which to occur; e.g. a die or a coin to be thrown, a radium atom to await possible decay, parents to conceive a child. *Ex hypothesi* the whole material universe could not issue from a distinct material chance set up, either temporally or atemporally. The concept of an immaterial chance set up is not a happy one (Mellor 1973)  
476.

### *The Probability of the Fine - Tuning*

The fine-tuning of the universe concerns the instantiation of the physical universe. There is no *material* chance set up in which the fine-tuning could have occurred. This seems enough to discount the propensity interpretation as well. However, there is hope for the propensity interpretation or some reformulation of it. Later I examine an explanation of the fine-tuning that suggests the universe is the product of a quantum vacuum fluctuation. If we consider the quantum field as an *immaterial* chance set up we may be able to characterise the probability of this universe using the propensity interpretation.

Further, the propensity interpretation motivates the notion of ontic probability. If we embrace the notion of physical indeterminism in the form of quantum theory, and if we are to consider physical indeterminism probabilistically, then it seems that we must also accept some form of propensity interpretation of probability, because no other current interpretation of probability accommodates physical indeterminism. Certainly, the propensity theory has been criticised as not conforming to the calculus (Salmon et al. 1992) 80. But the calculus itself is not beyond challenge. Leslie considered the possibility that some aspect of the fine-tuning (in the form of phase transitions) could have been set probabilistically and suggests that, if probability theory cannot accommodate developments in probabilistic physics, then it is probability theory not physics that should be revised (Leslie 1989) 112. Indeed the notion of ontic probability space may provide the basis of the 'immaterial chance set up' mentioned by Mellor. Clarifying our understanding of ontic probability space is no simple matter. But this is no reason to eschew an ontic probability space that makes sense of the *ontic* probability of the fine-tuning. Davies mentions a similar idea. When considering the probability of the fine-tuning he writes;

The problem is that there is no natural way to quantify the intrinsic improbability of the known "coincidences."... What is needed is a sort of meta-theory – a theory of theories – that supplies a well-defined probability for any given range of parameter values. No such theory is available, or has to my knowledge been proposed (Davies 1993) 205.

With respect to the *current* fine-tuning debate subjective degrees of belief, relative frequency, and propensity interpretations of probability do not seem viable. (I will review the possibility that a propensity interpretation is appropriate later.) This leaves

the logical and classical interpretations. Although there are differences between the logical and classical interpretations there are significant similarities. The similarities relate to the partitioning of the probability space, and the determination of the prior probabilities of each partition in the space.

I take the classical interpretation to refer to probability spaces that are finite and discontinuous, where each possibility has equal probability. As yet we do not know the nature of the probability space of universes, and to use the classical interpretation would unnecessarily restrict our ability to map it, so the classical interpretation does not seem appropriate. I take the logical interpretation to refer to probability spaces that are infinite and continuous, where each possibility may or may not be equally probable. Given that we do not know the nature of the probability space of universes, the logical interpretation seems the best option because this interpretation gives us the greatest flexibility in our attempts to map it. Notice that if I stipulate that certain points in the logical probability space have probability zero, and further stipulate that all points with non-zero probability are equally probable, then logical probability space can represent classical probability space. So, even if the classical interpretation is appropriate to map the probability space of universes, I can use the logical interpretation to do this as well. So let us assume that the appropriate interpretation of probability for the fine-tuning debate is the logical interpretation. Now let us look at the debate to see if the logical interpretation is used.

### *7.2.2 Interpretations in the current debate*

Swinburne distinguishes three types of probability: physical, statistical and inductive (Swinburne 2004) 14-15. We can consider these as equivalent to the propensity, frequency and logical interpretations respectively. In the fine-tuning debate Swinburne explicitly states that he is using the inductive (logical) interpretation of probability (Swinburne 2004) 16.<sup>100</sup> Leslie is less explicit with respect to which interpretation he

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<sup>100</sup> While Swinburne characterise himself as using an inductive (logical) interpretation of probability in his application of confirmation theory, he also uses the notion of simplicity in the consideration of the prior probabilities. Thus, in addition to his inductive (logical) position, he could also be characterised as an

### *The Probability of the Fine - Tuning*

uses. He believes that probabilistic language is appropriate in the case of isolated events. He claims that even if this universe is the only universe, it can still be considered *improbable*. One example he uses to support his claim is a coin that is tossed once. He argues that it is not nonsense to say that the coin had a half chance of landing heads (Leslie 1989) 110. So clearly he is not using a (strict) frequency interpretation of probability. Other comments he makes indicate that he is not using a subjective interpretation.

Well reasoned judgements of what is likely need not be dogmatic assertions about probabilities 'out there' in the world, but neither need they be mere reports on anything as personal as the strengths of our beliefs. They can be genuinely well reasoned and undogmatic. In making them we are often in effect judging that *if* certain situations were governed only by the factors so far believed to be relevant then such-and-such outcomes *really would be* probable 'out there'. For instance, if the die is in fact falling in obedience only to laws of dynamics and not to those governing a die with an internal iron lump which is being attracted by a powerful hidden magnet, then.... (Leslie 1989) 200-201.

These comments suggest that Leslie is using a logical interpretation of probability. But we should be cautious here. Leslie believes that, in probabilistic physics, the nature of probability theory (the structure of the calculus and the interpretations of probability) should not dictate what is and what is not *probabilistic*. In his words, "Probabilistic physics should not be imperilled to suit philosophers" (Leslie 1989) 112. This mention of probabilistic physics reminds us that the fine-tuning could have been set probabilistically.

A possibility treated with respect nowadays is that our universe underwent one or more phase transitions involving the splitting apart of Nature's four main forces. The forms, *themselves settled by Chance*, which these phase transitions took, could have fixed the relative strengths of those forces, the masses of various particles, and other affairs (Leslie 1989) 111.

These passages indicate that Leslie may support a propensity interpretation. While a propensity interpretation (or an ontically probabilistic interpretation) of the fine-tuning

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'Objective Bayesian' where this label indicates those who look for rules that would uniquely determine the prior probabilities (Howson 2001) 112.

faces the challenge of Mellor's unease with respect to an 'immaterial chance set up', Leslie is happy at least to consider the possibility. On the whole, while taking into account Leslie's consideration of ontic probability in the form of probabilistic phase transitions, it seems acceptable to characterise him as using a logical interpretation of probability.

Now let me turn to the physicists. There is an important way in which the philosophers and the physicists differ in their approach to probability in the fine-tuning debate. Both the physicists considered here generally approach the question of probability *with specific scientific theories in mind*. This approach is relevant to the issue whether probability is ontic or epistemic. The fact that probability is considered *in the domain of a theory* may mean that probability is epistemic. If the probability of the fine-tuning is a characteristic of the description of the universe, but not a characteristic of the universe itself, then the probability is epistemic not ontic. If the probability is part only of the theory, then the probability exists only in our minds not in the world. But setting aside the ontic status of probability for now, what interpretation of probability are the physicists using?

Hawking's clearest statement about probability relates to his consideration of the 'chaotic boundary conditions theory' (Hawking 1989) 129. This theory assumes the universe is either spatially infinite or that there are infinitely many universes. Further the theory assumes that the values of the initial conditions of the universe may vary over an infinite range and that any of these values is equally likely. Subject to the qualification that these remarks are made specifically in relation to this theory, it appears that Hawking is interpreting probability in a logical sense and further that he is assuming each possibility has equal probability. Hawking is aware that the application of the probability calculus in an infinite context leads to probabilities of measure 0 (Collins and Hawking 1973) 319. Nonetheless he seems comfortable with probabilistic language in this context. Apparently he is happy for intuitions about probability to take priority over the demands of the probability calculus, and it is worth remembering Leslie's similar comment (Leslie 1989) 112.

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Like Hawking, Davies considers the question of the probability of the fine-tuning by considering it in the context of theories of the universe, not the universe itself. When considering the cosmic initial conditions of the Hartle and Hawking model, he comments that this set of initial conditions is "only one of an infinite range of possible choices" (Davies 1993) 168. But Davies is more cautious when it comes to the probabilistic interpretation of the situation. He notes that "discussions which start out with observations of only one universe and go on to make inferences about the improbability of this or that feature, raise some deep issues concerning the nature of probability theory" (Davies 1993) 220-221. Further he specifically does not support the principle of indifference (Davies 1993) 205. Davies notes that where features of the universe can vary in an infinite number of ways, there is no way to determine the improbability of any universe. He argues that until there is a meta-theory that sets the range of values and probability distribution of those values associated with features of a potential universe, then any determination of the improbability of those values is subjective.

An important point about Davies' position is that the identified inability to determine the improbability is not a reason to exclude consideration of the probability of this universe from the debate. Davies seems to allow subjective estimations of probability to have argumentative force. While he is aware of different intuitions at work, when considering the fine-tuning he comments; "Even the most hard-nosed sceptic must surely be tempted to conclude that there was 'something going on'" (Davies 1993) 204. However these comments do not indicate that he is using a subjective interpretation of probability. His comment regarding a meta-theory indicates that he believes that such a meta-theory will contain an indeterministic (ontically probabilistic) element, and this is not how subjective probability is usually understood. Given our current understanding of physics, he seems to prefer to remain agnostic about the probability of the fine-tuning.

Finally, Davies makes interesting comments in relation to the pursuit of a *theory of everything* and the possibility that the universe is the product of an indeterministic process. One of our current best scientific theories is quantum theory. We understand quantum theory to be inherently indeterministic. The *theory of everything* project is the

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attempt to combine quantum physics with general relativity. Davies notes that if quantum theory is part of our final theory of everything, then at best such a theory would “fix some sort of most likely world” (Davies 1993) 169. However it is important not to misinterpret Davies’ comments. There is no reason whatsoever that a single universe instantiated by some quantum process would *be* the “most likely world”. An indeterministic system may well *fix* “some sort of most likely world” but a single world instantiated by such a process would not necessarily *be* that “most likely world.” The existence of a single, very improbable world is completely consistent with that world being generated by an indeterministic process. In summary, Davies appears to be agnostic about the probability of any specific universe and is willing to entertain subjective probability estimations. But interestingly, he also considers the possibility that the fine-tuning may have been set by some ontically probabilistic process that could be understood in the form of a ‘meta-theory’.

#### *7.2.3 Is the fine-tuning improbable?*

Let us grant that the logical interpretation of probability is appropriate in our consideration of the fine-tuning, and further that this interpretation generally seems to be the one used in the debate. Now given a logical interpretation, is the fine-tuning improbable? Many involved in the debate think that it is, or at least that it would be in the absence of God. But finding explicit statements to that effect is not straightforward. The problem is that much of the writing in this debate is phrased in ‘fine-tuning’ language rather than ‘probabilistic’ language. But there are some explicit statements. Swinburne reviewed the work of various scientists relating to the fine-tuning and he claims that the “present consensus of evidence is that certain *a priori* very unlikely features of laws are necessary for the occurrence of carbon-based life” (Swinburne 1991) 305. Clearly Swinburne accepts the fine-tuning to be *a priori* improbable. Let me now look at the probability space to see if this claim is justified.

### 7.3 The probability space of universes

#### 7.3.1 Considering the probability space

My task is to determine whether it is reasonable to claim that the fine-tuning of the universe is improbable. Thus I will consider the probability of this universe in the probability space of universes. In the possibility space we considered above, each distinct possible universe is specified by a set of co-ordinates in  $n$ -dimensional space. Now we can assign probabilities to each of these different universes by assigning a probability to each point in the space.<sup>101</sup> When considering the probability of this universe, and assuming an infinite probability space, we must acknowledge the *measure zero problem*. When standard probability theory is applied, any finite volume considered as a proportion of an infinite volume has a probability of zero. The problem of this universe having a probability of zero has been documented in the literature (Colyvan, Garfield, and Priest; Holder 2002; McGrew, McGrew, and Vestrup 2001). The solutions to this problem are less clear.<sup>102</sup> We will not resolve the problem here. So while acknowledging it, let us move on.

Let us begin with the assertion that, if other universes are possible, then they are equally as probable as this universe. So we start with the assertion of the principle of indifference. Later we will consider the probability space of universes without this assertion, but it is convenient to begin our analysis using this principle. Thus the probability space is uniform. The advantage of a uniform probability space is that we

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<sup>101</sup> This characterisation of probability space is developed from the 'phase space' characterisation used by Dowe in the manuscript "The Inverse Gambler's Fallacy Revisited: Multiple Universe Explanations of Fine Tuning" (Dowe).

<sup>102</sup> The simplest solution is to argue that the prior probability of this universe is self-evidently greater than 0. This argument is straightforward. Given that this universe exists, its existence cannot be impossible, so it must have a prior probability greater than 0. (This should not be confused with the quite distinct argument, also based on the existence of this universe, that the *posterior* probability of this universe is 1.) Although this solution has intuitive appeal and could be supported by arguing from the requirement of 'total evidence', it does not remove the contradictory fact that (without the use of infinitesimals) the application of probability theory in this situation yields a probability of 0. Another option is to deny that the probability space is infinite. But denial of an unbounded and/or continuous space just to avoid the measure zero problem is vulnerable to the charge of arbitrariness.

can calculate the probability of specified universes. We do this by calculating the ratio of the volume of space representing the specified universes to the volume of the total space. This ratio is the probability. Notice that it is necessary to move from specifying a single universe to more than one universe. This is because a single universe (specified by a point in the probability space) will have 0 probability (because a point has no volume). This move from one universe to a group of universes may seem imprecise, however it is sufficient for our purposes, and it conveniently allows for the fact that universes that are 'arbitrarily close' to this universe are also taken to be life-allowing (Collins 2003) 179.

In considering the probability space of universes, I again employ the graphical illustration (a Cartesian field of 2 dimensions), used in the previous analysis of probability space. This allows us to illustrate the probability of possible universes conveniently in two dimensions. The x-axis represents different universes and the y-axis represents the probability of each universe. There are limitations to this representation. When considering the probability space of possible universes we face the fact that (logically) there are an infinite number of such universes, and this leads to the problem that any distinct universe (or finite set) has a probability of 0. To avoid this problem (and the problem of a point having no volume), I consider the total probability space as a finite interval of the x-axis and I represent each distinct universe by further finite intervals within the larger finite interval. We can then consider the probability of universes in the probability space.

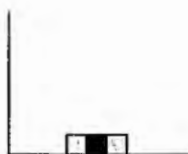
Possible universes are divided into life-allowing (black) and life-precluding (grey). Impossible universes are illustrated by positions on the x-axis with no value on the y-axis, because they have probability of 0. In all these diagrams the area of the graph represents the total probability space. Before we consider options, I stress that in considering an option, I do not suggest that it is *the* ontic probability space. I am simply illustrating the potential ontic probability spaces consistent with the data. Let us begin with our universe, Figure 7:1. We know that it is life-allowing and we know that it is possible, because it is actual.

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*Figure 7:1 the probability of our life-allowing universe.*

Obviously this means little, because we have nothing with which to compare it. What are the options? If this life-allowing universe is the only ontically possible universe, then there is literally nothing else to compare it to. This universe occupies the total probability space; its probability is 1, and the probability of other universes is 0.<sup>103</sup> But let us grant that other universes are ontically possible. The data of the fine-tuning tells us that universes slightly different from ours are not life-allowing so we can add this information to the graphical representation, Figure 7:2.



*Figure 7:2 The probability of life allowing universes in the local area.*

Now we have more information about the probability of life allowing universes, and so (as we are assuming equi-probability across universes) we might claim that this life-allowing universe is improbable. But this is too quick. I would be more comfortable if I knew what was happening beyond the local area. So again, what are the options? Let us assume that all logically possible universes are ontically possible. What might distant regions of the probability space be like? Figure 7:3 illustrates some options.

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<sup>103</sup> Here I am not asserting that this universe is ontically necessary; that would imply that it must have existed. In this scenario I am only asserting that if a universe exists at all, then this universe will exist.

## *The Probability of the Fine - Tuning*



*Figure 7:3 potential probability distributions in continuous probability space.*

The left hand graph represents the probability space where our universe is the only life-allowing universe. If this is the case it does seem to be improbable. The centre graph represents the chaotic universe theory discussed previously. In this situation, life allowing universes are not improbable; they just do not occur adjacent to each other. Notice that in one sense they are *all* fine-tuned.<sup>104</sup> The right hand graph illustrates the fact that although there are no other life-allowing universes in the local area, they may be common in distant regions. This is the possibility considered by Leslie in his local area argument (Leslie 1989) 17. We might be tempted to say that life allowing universes are not improbable in this situation. But it is noteworthy that even here, where life allowing universes are common in distant regions, there does seem to be an interesting sense in which life allowing universes are 'improbable' in the local area.

We have been considering continuous probability space. Let us now consider a discontinuous probability space, where there are logically possible locations in the space that are not ontically possible. This concept is equivalent to the quantised possibility theory that we considered in a previous chapter. For reasons similar to those that limit quantum events in the physical world, possible universes also may be limited, such that not all logically possible universes are ontically possible. Ontically impossible locations have a probability of 0. So the ontic probability space is discontinuous, as illustrated in Figure 7:4.

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<sup>104</sup> The notion of fine-tuning here is confounded by the fact that universes that are 'arbitrarily close' to other universes are not fine-tuned with respect to those other universes. But if we considered *groups* of arbitrarily close universes, then a particular group can be fine-tuned with respect to other groups.

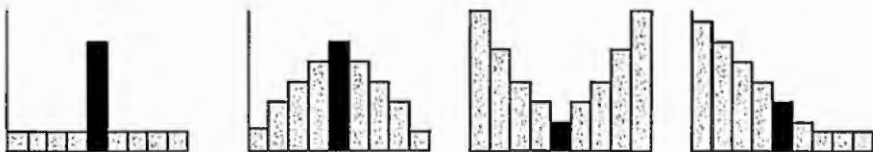
### *The Probability of the Fine - Tuning*



*Figure 7:4 potential probability distributions in discontinuous probability space.*

Again the left hand graph presents the probability space if our universe is the only life-allowing universe. The centre graph represents the quantised version of the chaotic possibility space, and the right hand graph represents the situation in which distant regions of the probability space are all life-allowing.

Given all this, what can be said about the probability of this universe? The simple fact is that we can say very little. We do not know enough about distant regions, or the nature of the probability space. All the probability distributions that we have considered in the above discussion are compatible with the fine-tuning data; namely that 'slightly different' universes preclude the existence of life. But it gets worse. Throughout this discussion we have kept things simple. We have assumed that all possible universes are equally probable, but there is *no justification* for this assumption. The probability space of possible universes may not be uniform, and it could be non-uniform in an infinite number of ways, *all compatible with the fine-tuning data*. Consider Figure 7:5. For simplicity, only one possible version of the ontic probability space is illustrated (where there is only one life-allowing universe in a continuous space of possible universes). This is but one of the probability spaces we have considered, and the 'real' ontic probability space of universes may take another form.



*Figure 7:5 potential probability spaces of ontically possible universes.*

Which of all the possible probability distributions of universes is the ontic probability distribution? The answer relates to Davies's reference to a meta-theory that will define this ontic probability distribution, and although I explored chaotic and quantised possibilities I leave the detail of such theories to physicists. To avoid the complications that these possible probability distributions create, I return to my assumption that all possible universes have equal probability.

### *7.3.2 What probability space are we talking about?*

I contend that we cannot make conclusive claims about the proportion of life-allowing universes in the total logical probability space. Thus there does not seem to be any way to justify the idea that life-allowing universes are improbable in the total logical space. But what if we consider less than the total logical probability space? Is there then a reasonable sense in which this universe is improbable? Perhaps. This relates to whether the fine-tuning debate is concerned with the *total logical* probability space, or some *other* probability space. This is an interesting issue. Indeed it may be that different theorists in the debate deploy different probability spaces. So what are the options?

One option is the total logical probability space. This space is continuous and unbounded, and leads to the *measure zero* problem, the *slight difference* problem, and the *no knowledge of distant regions* problem. The other option is a probability space less than the total logical probability space. Depending on the nature of the limitation of the logical space this may or may not solve these problems.<sup>105</sup> The fundamental question is whether there is a non-arbitrary way to choose a probability space that is less than the total logical space. If a non-arbitrary way can be established, then we can ask whether

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<sup>105</sup> If the space is unbounded and continuous we have not solved either the measure zero problem or the no knowledge of distant regions problem. But if the space is bounded and we have total knowledge of the bounded region under consideration, this solves the no knowledge of distant regions problem. However this approach faces the charge of arbitrariness. There needs to be some non-arbitrary reason for limiting the space to less than the total logical possibility space. Further, if we choose a finite volume of the probability space, then this also solves the slight difference problem. If the bounded region is continuous we have not solved the measure zero problem (unless we move from considering a single universe to a finite range of universes in the bounded region). However, if the region is bounded and discontinuous, we could solve the measure zero problem, if the nature of the discontinuous space does not involve infinities.

this universe is improbable with reference to that space. Thus, we are interested in the question of what part of the space is relevant to the calculation of the probability of this universe.

Leslie's *local area argument* is relevant here. Leslie claims that using knowledge only of the *local area* there is a meaningful sense in which this universe is improbable. Leslie's approach relies on a distinction between *limiting* the probability space to less than the total logical space and *considering less than* the total logical probability space. Leslie argues that *without limiting* the total logical probability space, we can take this universe to be improbable, by *considering* only the local area. In this way Leslie implicitly avoids the charge of arbitrarily limiting the space. We know little about the total probability space, but we do know something about our local area. Is our knowledge of the local area enough to determine whether this universe is improbable?

### *7.3.3 The local area argument*

Leslie believes that it is reasonable to consider only the local area of universes and further that such a consideration justifies the position that this universe is improbable. Leslie uses an analogy to represent the fine-tuning of the universe. The analogy involves a wall with flies on it, and a bullet fired at the wall (Leslie 1989) 17-18. Locations on the wall (either with or without a fly) represent different universes with different laws and/or initial conditions. Locations on the wall with flies represent life-allowing universes. The bullet hitting a fly and/or the wall represents the instantiation of a universe. The bullet hitting a fly represents the instantiation of a universe that allows for life. The bullet hitting the wall (without hitting a fly) represents the instantiation of a universe that does not allow for life. Leslie represents the fine-tuning of the universe as a bullet hitting a single fly (or a small group of flies) surrounded by empty wall.

Importantly he also says that distant parts of the wall may be *thick with flies*. So imagine a wall with many flies on it. (Further imagine that it is an infinite wall – Leslie does not specify this but this specification will be convenient to accommodate aspects of this discussion, and it does not affect Leslie's position.) Most of the wall is thick with flies such that a bullet fired randomly at the wall would hit a fly. But there is at least one area

of the wall where there is one fly (or a small group of flies) surrounded by empty wall such that a bullet fired randomly would ‘probably’ not hit a fly in that area.

For Leslie the need to explain an event is intimately related to its apparent improbability. In this analogy Leslie does not separate the improbability of an event from the need to explain that event. Following Leslie we will consider the *need to explain* the event, but for current purposes I take this as equivalent to the event being improbable.

Leslie’s position is this. The fact that a bullet hit a fly *that was surrounded by empty wall* requires explanation (was improbable). Notice that it is not only the fact that the bullet hit a fly that requires explanation. The fact that needs explaining (is improbable) is that the fly that was hit *is surrounded by empty wall*. So for Leslie, the relevant fact that needs explaining (is improbable) is not that the universe is *such that* it allows for life, but rather that it is *fine-tuned* to allow for life. This distinction is not generally acknowledged in the fine-tuning literature. As mentioned Leslie does not explicitly separate his argument about the *probability* of the fine-tuning from his argument about the *need to explain* the fine-tuning and this may help to explain why the distinction between ‘life-allowing’ and ‘fine-tuned for life’ is not more widely acknowledged. (I examine Leslie’s argument for the need to explain the fine-tuning later.) But for our present purposes, we need to understand that he *implicitly* uses probabilistic argument to get from the bullet hitting the fly surrounded by empty wall to the need to explain that event.

Let us consider the analogy, assuming an infinite wall. If the bullet could have hit the wall anywhere, then the probability that the bullet hit any specific finite area of wall would be 0. Leslie does not limit the probability space at all. He is willing to include the total probability space. At all times in the Fly on the Wall story the bullet could have hit anywhere on the wall, including areas thick with flies. So I take it that Leslie accepts an infinite probability space. While he acknowledges that the bullet could have hit the wall in a distant region ‘thick with flies’, the important point for Leslie is that *in fact* the bullet hit a fly *surrounded by empty wall*. For Leslie this is what requires an explanation.

The main point of the Fly on the Wall Story is that any need for an explanation is fully compatible with supposing that most flies on the wall are

in areas thickly covered with flies and – *that* is equivalent to saying that, for all one knows or cares, it could be that in almost all possible life-containing universes Life *would not* depend on any ‘delicate balancing’ or ‘fine tuning’. All we need know or care about is the fact that *our universe* is one in which Life depends on fine tuning. *Our* fly, so to speak, could be hit only by a bullet travelling just rightly: hence (at least plausibly) Multiple Bullets or Marksman (Leslie 1989) 162.

Leslie is not vulnerable to the charge of arbitrarily limiting the probability space simply because he *does not limit* the probability space. Further, Leslie grants that distant regions may be ‘thick with flies’. So not only does he not restrict the probability space, he grants that life-allowing universes may be very probable relative to the total probability space. So he does not arbitrarily limit the space. His position is that the whole space is not relevant to the need to explain this universe. This need is driven by the characteristics of the local area.

... you mustn’t attack anthropic reasoning by saying that it involves making claims about the rarity of Life and Intelligence in the field of all possible universes. Yes, any such claims might indeed go too far beyond our evidence; but the user of anthropic reasoning need not make them, as is shown by the tale of the Fly... If a tiny group of flies is surrounded by a largish fly free wall area then whether a bullet hits a fly in the group will be very sensitive to the direction in which the firer’s rifle points, even if other very different areas of the wall are thick with flies. So it is sufficient to consider *a local area of possible universes*, e.g. those produced by slight changes in gravity’s strength, or in the early cosmic expansion speed, which reflects that strength. It certainly needn’t be claimed that Life and Intelligence could exist *only if* certain force strengths, particle masses, etc. fell in certain narrow ranges. For all we know, it might well be that universes could be life-permitting even if *none* of the forces and particles known to us were present in them. All that need be claimed is that a lifeless universe would have resulted from *fairly minor* changes in the forces etc. with which we are familiar (Leslie 1989) 138-139.

While I find Leslie’s argument attractive, I feel that his analogy of flies and bullets is vulnerable to anthropocentric bias. When using analogies it is important to avoid suggestive images, and bullets are rather suggestive of a marksman. Having said that, it is not easy to find an analogy that is completely free of suggestion. However, I believe the following analogy to be less biased, because meteors (arguably) can be considered due to natural or supernatural forces. Consider the surface of a planet with a large land area and a smaller ocean area. The land forms one large continent and one small

island. Now consider a meteor that hits that planet. Leslie's point is that it is improbable (requires explanation) that the meteor hits the island, even though it is not improbable (does not require explanation) that the meteor hits land.

In the past Swinburne took a similar line to Leslie (Swinburne 1991). He appreciates the problems associated with the estimation of the improbability of this universe if we include all logically possible universes. He considers that it is not possible to come to any 'moderately precise' estimate of the probability if all logically possible options of the laws and boundary conditions are considered.

Our judgements as to just how narrow are the ranges in which crucial variables of boundary conditions and some of the constants of scientific laws have to lie in order to permit the evolution of intelligent life must be very tentative. However, the significant balance of evidence... is that, given boundary conditions and physical laws of the kind which in fact operate on our universe, these variables have to lie in very narrow ranges... Now certainly if we vary a number of different constants, or even change the laws entirely, and alter the boundary conditions in a large way... then no doubt intelligent life could evolve as a result of quite a different mechanism. There is no logical necessity tying its evolution to the particular laws and boundary conditions which we have. But the crucial point is that any slight variation in these would make life impossible (Swinburne 1991) 310.

Any moderately precise estimate of what proportion of logically possible laws and boundary conditions would allow life seems impossible. There is no obvious way of setting about counting here. All that is clear is that, in the kind of region of laws and boundary conditions for which we can get some feeling of proportions, the range allowing life is probably very small indeed (Swinburne 1991) 311.

However, more recently, Swinburne has moved away from this position (Swinburne 2004). In a footnote, Swinburne writes, "if the fact that there is a tuned universe is to be evidence for God being its creator, what has to be shown improbable *a priori* is not that there be a tuned universe in our local area of possible worlds, but that there be a tuned universe among all possible worlds" (Swinburne 2004) 185.

So is it justifiable only to consider the local area? Leslie thinks it is. Until recently Swinburne appeared to agree. Further, is it justifiable to claim that this universe is improbable based on consideration only of the local area? Mark Colyvan, Jay Garfield

and Graham Priest argue that such a move is arbitrary. They suggest that, using this approach, it is not *this universe* that needs fine-tuning, but the *local area* that needs fine-tuning to get the desired improbability (Colyvan, Garfield, and Priest) 7. To a certain extent they are correct. Indeed it is possible to gerrymander the 'improbability' by choosing where in the probability space to draw the line. Improbable life-allowing universes could then be gerrymandered by drawing the line just inside the area 'thick with flies'. But this criticism seems unfair to Leslie. It is unfair simply because Leslie is not doing this. Leslie does not ignore data or gerrymander the space. He uses all the available data. Further, he does not make convenient assumptions about data that he does not have. Leslie concedes that distant regions may all be life-allowing, and still he maintains that the nature of the local area is such as to warrant further consideration. Leslie's argument is based only on knowledge of the local area. The nature of the local area is that universes slightly different from our own do not allow for life (Leslie 1989) 2-3.

Leslie can justifiably use the local area to determine the probability of the fine-tuning. He has met the charge of arbitrariness, because he has not restricted the probability space at all, and yet there seems to be a reasonable sense in which this universe is fine-tuned for life. Assuming that we can use the local area to determine the probability of the fine-tuning, the next question is this: is this universe improbable? So now (using the local area) let us consider whether it is reasonable to claim that this universe is improbable.

#### **7.4 Partitioning the probability space**

I have argued that there are two ways to partition the probability space: non-demonstratively  $\{A, B, C, \dots\}$  and demonstratively  $\{A, \neg A\}$ . Consider Figure 7:6. Each distinct possibility is represented by a position on the x-axis and the probability of each possibility is represented on the y-axis, and, as we are assuming for ease of analysis that this is an equi-probable situation, each possibility has the same probability. Here the finite intervals on the x-axis serve as the non-demonstrative partition.



**Figure 7.6** *non-demonstrative/demonstrative partitions of equi-probability space*

In the left hand diagram the equi-probable probability space is partitioned non-demonstratively. Every universe (or finite interval of universes) is equally probable; no universe is more nor less probable than any other universe, so it is difficult to understand the meaning of probable or improbable in this situation. For this discussion, say that there are 100 possible universes, one of which will be instantiated. Then every universe has a probability of  $1/100$  of being instantiated. No universe has a probability greater than  $1/100$  and no universe has a probability less than  $1/100$ . So no universe is more nor less probable than any other. Thus, as argued previously, given that 'improbability' is essentially a relative notion, it is not appropriate here to call any universe improbable, the appropriate term is 'isoprobable'.

The only way to justifiably use the phrase 'improbable' with respect to any particular universe, in an equi-probable situation, is to use a demonstrative partition to create *differential* probability. The centre diagram is a demonstrative partition with one of the possibilities distinguished from all the other possibilities. In this case 'life-allowing' is distinguished from 'not life-allowing'. Now there is a real sense in which 'life-allowing' is improbable, but only due to the demonstrative partition. The same partition is illustrated in the right hand diagram. Here it is clear that the probability space has only two possibilities, 'life-allowing' and 'not life-allowing'. Now it is obvious how 'life-allowing' can be considered improbable relative to 'non-life-allowing'. But note that the improbability only exists because of the demonstrative partition. If there is no reason to partition the space this way, then there is no justification for the claim of improbability. The improbability created by the demonstrative partition is meaningful only if the partition itself is justifiable.

*7.4.1 Justifying the demonstrative partition*

How do we justify the claim that 'life-allowing' is different to 'non life-allowing'? Is there an objective demonstrative partition to be made between universes that allow for life and universes that do not? One could say that life-allowing universes are self-evidently different from non life-allowing universes, so no justification is required. It is uncontroversial that there are *subjective* justifications for the demonstrative partition. Certainly 'life-allowing universes' are subjectively different from 'non life-allowing universes' *to those who are alive*. But a subjective justification is not sufficient, because it will not convince those who hold a different subjective position. We need an objective difference to justify the demonstrative partition.<sup>106</sup>

I will not determine whether there are *in fact* objective justifications for (demonstratively) partitioning life-allowing universes from non-life-allowing universes. But I need to make explicit the implication of the distinction between objective and subjective justifications for the demonstrative partition. The objective justification depends on an objectively significant difference between 'life-allowing' and 'non-life-allowing' universes. Without objective significance the demonstrative partition cannot be defended against the charge of subjectivity.

To be clear there are objective *differences* between life-allowing and life-precluding universes. One objectively allows for life and one objectively does not. But why is this a basis for a partition? To justify an objective demonstrative partition there needs to be some objective significance to the fact that some universes allow for life and others do not. To illustrate this point consider the alternate demonstrative partition based on whether a universe allows for *light*: {light allowing,  $\neg$ light allowing}. In what sense is the {life-allowing,  $\neg$ life-allowing} demonstrative partition justified *objectively* where

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<sup>106</sup> Consider also the case of a universe that is 'life-allowing' but in which no life actually exists. Is this life-allowing but lifeless universe significantly different to a lifeless universe that does not allow for life?

the {light allowing,  $\neg$ light allowing} is not? There does not seem to be any objectively significant feature that distinguishes these two potential demonstrative partitions.<sup>107</sup> Demonstrative partitions are fundamentally based on subjective significance or interest. If there is an objective justification for the demonstrative partition, then the partition can support the claim that the life allowing universes are improbable. But without the objective justification there is no foundation for the demonstrative partition and hence no objective sense of improbability.

Recall the series of coin tosses considered in the previous chapter: HTTHHTTHT. If there is an objective sense in which this series is significantly different from any other series, then we can justify a demonstrative partition. But if there is no objective sense in which this series is significantly different from any other, then we cannot justify the partition. If we cannot objectively justify the demonstrative partition, then the only objectively justifiable partition is a non-demonstrative one. But based on a non-demonstrative partition all possibilities are equally probable. So there is no meaningful sense of improbability.

Consider the roll of a die. Is the roll of a 'three' significantly different from the roll of any other number? Obviously there can be a subjectively significant difference. If we have placed a bet that the die will show 'three' and it does, then there is a subjectively significant difference. But this is not objectively significant. There is no objectively significant difference between a roll of a 'three' and the roll of a 'four'. Without objective significance justifying the demonstrative partition, the only objectively justifiable partition is the non-demonstrative partition: {1,2,3,4,5,6}. Based on the non-demonstrative partition the roll of 'three' is no more or less probable than any other number. So there is no objective sense of the roll 'three' being improbable.

The fine-tuning of the universe is analogous. If the fine-tuned (life-allowing) universe is different from other (non-life-allowing) universes, in an objectively significant sense,

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<sup>107</sup> Note that there are life forms based on *chemosynthesis* that do not rely on the light of the sun for energy (Curtis 1983) 982. So theoretically, universes can be life allowing without being light allowing.

then we can justify the partition objectively. If we can do this, then there is an objective sense in which the universe is improbable. But if we cannot objectively justify the demonstrative partition, then there is no objective sense in which this universe is improbable. So what could be the basis of an objective demonstrative partition?

#### *7.4.2 Is 'life' objectively significant?*

If life is objectively significant, then this justifies the demonstrative partition between 'life-allowing' and 'non life-allowing' universes.<sup>108</sup> I will not address the question of the objective significance of life here. But I believe this to be the fundamental question at the centre of the fine-tuning debate. Put simply if one believes that life is objectively significant, this motivates the demonstrative partition, which in turn generates the improbability which then prompts the need for explanation. On the other hand, if one does not believe that life is objectively significant, there is no motivation for the demonstrative partition, and thus no generation of improbability and no need for an explanation.

Some argue that life is objectively significant, but others argue that it is not. Presumably Swinburne believes that life (at least in the form of intelligent organisms) is objectively significant. He argues at length that God would want intelligent organisms (Swinburne 1991) Chapter 9. On the other hand, Scriven presumably believes that life is not objectively significant. Recall his example of the  $6^{10}$  possible combinations of ten dice tosses. Each combination, he argues, has interesting properties, but this does not justify the combination that happens to occur to "sit and look at itself" and assume that it is significant in some objective sense (Scriven 1966) 129.<sup>109</sup> Note here that other theorists are cautious when considering this justification of the demonstrative partition. Leslie

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<sup>108</sup> Strictly speaking for this justification to be reasonable, life would need to be *certain*, not merely 'allowable' in such universes. After all, what would be the objective significant of a universe that allowed for life, but in which no life actually existed? However I will ignore this complication here.

<sup>109</sup> Scriven does not use the term 'objective'. He claims that the combination that happens to occur should not assume that the situation was manipulated such as to bring about its occurrence. But this is effectively equivalent to the notion of objectivity that I am considering.

does not justify the explanation of the fine-tuning using the objective significance of life (Leslie 1989) 120. Erik Carlson and Erik Olsson also have reservations about the 'relevant' partitioning of the space (Carlson and Olsson 1998) 260.

#### *7.4.3 Is the fine-tuning surprising?*

I claim an event is surprising if it does not conform to its epistemic probability. Further I argue that the occurrence of an isolated event conforms to all epistemic probabilities other than 0. An isolated event may be probable or improbable, but in the absence of information about whether the event has happened many other times, or never before, the event conforms to all epistemic probabilities other than the epistemic probability of 0. Thus an isolated event can only be surprising if we believe it to be impossible. Now with respect to the fine-tuning of the universe, given we only have knowledge of our universe, the universe is an event considered in isolation. Thus this universe is surprising if and only if we believe it to be impossible.

#### *7.4.4 A probabilistic ontic proposal*

At the end of chapter 5 I used a cube, a sphere and a plane to illustrate the distinction between logical and ontic possibility space. Now I use the same idea with probability space. Logical probability space corresponds to the sphere. When we consider the sphere, all logical possibilities have an equal probability of occurring, as it seems equally likely that any point on the sphere can be in touch with the plane. But logical probability space may not be the appropriate space. The ontic probability space may differ from the logical space. In the illustration, the ontic probability space corresponds to the cube. When the nature of the ontic probability space is clarified, it emerges that not all logical possibilities have an equal probability of occurring. In fact only six points on the surface of the sphere have any (non-zero) probability of touching the plane.

If we ignore the distinction between ontic probability space and logical probability space and if we are not aware of the structure of the ontic space, then we may make incorrect probability estimations for the possible states of a system. For example, if ontic probability space is quantised, then certain apparently possible universes are ontically

impossible. These universes have an ontic probability of zero and in the illustration correspond to all the points on surface of the sphere not also on the surface of the cube.

Previously the cube and sphere illustrated a quantised ontic proposal; this proposal can now be revised. We can look at all the logically possible universes in the probability space and conclude that this universe is improbable.<sup>110</sup> But we may be considering the sphere when we should be considering the cube. If ontic probability space is the cube rather than the sphere, then this fine-tuned universe is not improbable after all.<sup>111</sup> The universe is not really 'fine-tuned' at all. So my revised ontic proposal is this: ontic probability space is such that there is not an infinite number of different values that the fine-tuned features of our universe could hold. I propose that ontic probability space is quantised, and in such a way as to make 'slightly different' universes impossible or improbable, and this removes the improbability of this universe.

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<sup>110</sup> Or I could conclude that it has an isoprobability with a low numerical value.

<sup>111</sup> Or it has an isoprobability with a higher numerical value.

## 8 Indeterminism, Probability and Explanation

### 8.1 Responding to the improbability of the fine-tuning

In the first part of the thesis I examined the claim that the universe is fine-tuned and that this fine-tuning is improbable. I argued that there is good reason to question this improbability. But to continue, let us assume that it is meaningful to assert that the fine-tuning is improbable. Now consider the possible responses to that improbability. To begin let us consider the two basic types of response - that which rejects the improbability, and that which accepts it.

#### 8.1.1 *Rejecting the improbability*

Hawking is uncomfortable not only with the improbability but also with the apparent contingency of the fine-tuning; so much so that he laments; “Was it all just a lucky chance? That would seem a counsel of despair, a negation of all our hopes of understanding the underlying order of the universe” (Hawking 1989) 140. He suggests that science may uncover necessity in the fine-tuned constants and initial conditions. “It may be that one day we shall discover a complete unified theory that predicts them all...” (Hawking 1989) 131. Hawking’s reaction to the improbability, and more generally the contingency, of the fine-tuning is to seek necessity in the form of a unified theory that removes the apparent improbable contingency. Some physicists share this hope, although, notably Davies does not (Davies 2004) 167.

Another response to the improbability of the fine-tuning is the postulation of many other universes. These other universes are taken to be spatially and/or temporally distinct regions or domains within what has been called the *multiverse* (Davies 2004). There are several different versions of the multiverse theory, but they are all motivated by the same basic idea. The postulation of many universes is motivated by the now widely accepted theory that the values of certain parameters in the standard model of particle physics are set by a form of ‘symmetry breaking’ (Davies 2004) 728. This process of symmetry breaking is taken to imply that these values could have been different in different regions of the multiverse. These regions with different parameter values are

considered as different universes. If there were many universes with different characteristics, then it would not be improbable that at least one of those universes was fine-tuned. There are problems with this approach relating to the distinction between the improbability of the fine-tuning of *some* universe as opposed to *this* universe, which I consider later. But for the present purposes all that need be understood is that this response is an *attempt* to remove the improbability of the fine-tuning.

Another response to the improbability is to argue that although the fine-tuning would be improbable if it were only due to chance, it would not be improbable were it due to design. Swinburne argues that if there were a God who wanted intelligent organisms, then the fine-tuning of the universe (to allow for such an eventuality) would be probable. He uses confirmation theory to argue that the fine-tuning is evidence for God (Swinburne 1990). Given that the fine-tuning is more probable conditional on God than on chance, the fine-tuning 'confirms' the design hypothesis more than the chance hypothesis. So Swinburne rejects the improbability by arguing that the fine-tuning is not improbable if it is assumed that God designed the universe to allow for intelligent organisms.

### *8.1.2 Accepting the improbability*

The previous responses attempt to reject the improbability. However, the alternate strategy is to accept it. One response is to argue that, given the universe exists, it had to have some properties, and the fine-tuned values are the ones it happens to have. This response simply accepts the improbability of the fine-tuning of the universe as the way things are. Scriven makes this point with a die analogy.

What happened is just one of the possibilities. If we decide to throw a die ten times, then it is guaranteed that a particular one of  $6^{10}$  possible combinations of ten throws is going to occur (Scriven 1966) 129.

We could argue that this finely-tuned universe is one of the logically possible universes, so there is no need to explain it any further, but this seems unsatisfactory. Perhaps the need is for a process that is more satisfying than chance operating in logical possibility space. The die analogy is open to criticism because, while it rests on our understanding

of the way dice are used in our society, there is no obvious chance mechanism for the production of universes.

The final response I explore is the possibility that there is only one universe and it is the product of an ontic process analogous to a vacuum fluctuation of the quantum field. Quantum field theory allows for the spontaneous emergence of matter from a quantum vacuum; this is called a vacuum fluctuation. Tryon proposes that this material universe exists as the result of such a quantum vacuum fluctuation (Tryon 1990) 218. However, if our universe was the product of such an event, then the conservation laws require that the net energy of the universe be zero, but, Tryon argues, this is quite plausible. So it is consistent with the observed data, the conservation laws and quantum theory that the universe is the result of a vacuum fluctuation.

Note that vacuum fluctuation explanations are usually considered as multiple universe explanations. However, they need not be. The reason that they are considered as such is due to the motivation to avoid the improbability. If there are many universes (the argument goes), then it is not improbable that at least one will be fine-tuned. But there is no reason that the vacuum fluctuation explanation needs to be considered in a multiple universe framework. If we relinquish the need to avoid the improbability, then we relinquish the need for other universes. This strikes me as a good option.

### *8.1.3 The implications of indeterminism*

Our current science tells us that the world is in part indeterministic (Salmon et al. 1992) 30. Indeterminism is involved in at least two of the responses to the improbability of the fine-tuning that we just considered. Both in the multiverse response and the single quantum vacuum fluctuation response, the fine-tuned values are set by an indeterministic 'symmetry breaking' mechanism. To illustrate the nature of indeterminism consider the spontaneous decay of an atom. Our current understanding of atomic decay is that an atom has a probability of decay at each moment in time and that is the complete story. There is literally no reason for it to decay at any particular time (Hitchcock and Salmon 2001) 475. The probability of decay in any relatively short time interval is very small. Symmetry-breaking responses claim that this finely-tuned

universe is simply the improbable outcome of an indeterministic system. If we accept the reality of indeterminism, then we need to adapt our expectations with respect to the improbability of this universe and our ability to explain it *or explain it away*.

## 8.2 Considering explanation

I divided the responses to the fine-tuning with respect to their acceptance or rejection of improbability. This highlights the role that probability plays in belief choices.

Probability plays a central role in these responses, sometimes obviously, as in the case of Swinburne's argument for the existence of God, and sometimes less obviously, as in the postulation of many universes in an attempt to remove the improbability that *some* universe was fine-tuned. In both these cases there is a motivation to reject the claim that this universe is improbable. But notice that some other responses do not reject the improbability. Why is there a difference? Some responses attempt to make the fine-tuning more probable. For some, it seems that making the fine-tuning more probable is a good thing to do. Perhaps an improbable universe is unacceptable. Why? There are two possible reasons. Either because life is objectively significant, or because improbability means that the fine-tuning has not been satisfactorily explained.

### 8.2.1 Significance

Some people may feel that our existence is significant and that significant things cannot be improbable. Given that our existence is conditional on the fine-tuning, these people are uncomfortable with the fine-tuning of the universe being an improbable event. Here we need to distinguish objective and subjective significance. By subjective significance I mean that our existence is of significance *to us*. This is uncontroversial. However, objective significance is a different matter. I take objective significance to mean that our existence (or if you like life in general) has some significance independent from our own experience of it. The objective significance (or otherwise) of life is a major philosophical issue. I will not consider whether life is objectively significant here. But I note a point regarding the probability of the fine-tuning with respect to significance. If life is only subjectively significant, then there is no contradiction in it being improbable. If, however, life is objectively significant, then there is a problem with it being

improbable. I will not justify this position here but it seems to me that if life is objectively significant, then it simply does not make sense for it to be improbable. In fact, it seems to me that if life is improbable, then there is a defensible argument that it cannot be objectively significant. There seems to be a natural inclination, such that if a person believes for independent reasons that life is objectively significant, then this would lead them to reject the improbability of the fine-tuning.

### 8.2.2 *Explanation*

Now consider the rejection of the improbability of the fine-tuning as implying that the fine-tuning has not been satisfactorily explained. Explanation is a large topic in the philosophy of science, and I will not consider explanation *per se* in any detail. I will only engage with the aspects of explanation that relate to probability.

Explanation is an attempt to understand the world. So to begin let me distinguish the world (the ontic) from our understanding of the world (the epistemic). I assume that the ontic world exists independently from our understanding of it. Our understanding of the world, through explanation, is fundamentally epistemic. Explanations, by definition, must be comprehensible otherwise they are not explanations.<sup>112</sup> I assume that we are limited epistemic agents and that not all of reality is necessarily comprehensible.<sup>113</sup> In addition to our limited epistemic capacity there is also the fact that some features of reality simply do not have explanations. For example, science tells us that there is literally no explanation for why an atom spontaneously decays at a particular time. All that we can do is specify the ontic probability of the event (Hitchcock and Salmon 2001) 475. Now consider the correspondence between reality and our comprehension of reality. I take it as uncontroversial that ideally we want our beliefs about reality to match

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<sup>112</sup> Here I will ignore the complications of different levels of cognitive ability. I simply mean that an 'explanation' that is not in principle comprehensible by the average (or if you like the most intelligent) humans, is simply not an explanation.

<sup>113</sup> If we assume that our cognitive capacity is the product of evolution, then there are no obvious reasons why we should be able to comprehend all aspects of reality. Some aspects of reality may be literally incomprehensible.

reality. In the case of explanation, we want our explanations to be true. However, as limited epistemic agents we may get it wrong. We may make explanatory errors.

### *8.2.3 Ontic grounds and epistemic reasons*

To facilitate the analysis of explanatory error I employ two terms: ontic grounds and epistemic reasons.<sup>114</sup> I use the phrase 'epistemic reasons' here to refer to explanations. I have chosen the phrase to stress the fact that explanations are essentially epistemic. Epistemic reasons are necessarily comprehensible, and they may be true or false (in that they may or may not correspond with reality). Ontic grounds are reality. It is not possible for ontic grounds to be 'false'.<sup>115</sup> Ontic grounds may or may not be comprehensible.

Ontic grounds are what epistemic reasons attempt to map in the world. Notice that I have not called these ontic *reasons*, as the notion of a 'reason' may be purely epistemic. Notice also that I have said that ontic grounds are what epistemic reasons refer to in the world. But these grounds may not be 'reasons' as we understand this notion. Reasons (necessarily) are comprehensible, but as several philosophers have observed, the world is not necessarily comprehensible (Peterson et al. 1991). Thus I avoid the word 'reason' when referring to reality.

### *8.2.4 Explanatory errors*

Explanatory error occurs when epistemic reasons do not match ontic grounds. There seem to be two fundamental types. I call the first type of error *contingent explanatory error*. This concerns epistemic reasons for comprehensible ontic grounds. This error occurs when epistemic reasons do not match ontic grounds. However, since the ontic grounds are comprehensible, there is the potential for the epistemic reasons to match the ontic grounds. Thus these errors are contingent. An example of a contingent error is the

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<sup>114</sup> The term 'ontological ground' has been used by Smith (Smith 1997) 174.

<sup>115</sup> I do not use the word 'true' to refer to ontic grounds because, to me, the word 'true' implies comprehensibility, and this is an epistemic notion.

explanation of why the sun sets. "The earth is stationary and the sun revolves around the earth" is an epistemic reason that is erroneous. But it is contingently erroneous. It has the potential to be correct in the form of the explanation, "the earth rotates on its axis".<sup>116</sup>

Related to the notion of contingent explanatory error is the notion of *probabilistic explanatory error*.<sup>117</sup> This error occurs when our epistemic probability of an event does not accurately map the ontic probability of that event.

I call the second type of error *necessary explanatory error*. This error concerns incomprehensible ontic grounds. Necessary explanatory errors occur when we have epistemic reason for incomprehensible ontic grounds. As noted above epistemic reasons are comprehensible. If we have comprehensible reasons for an incomprehensible ontic ground these reasons will necessarily be erroneous.<sup>118</sup> An example of a necessary explanatory error relates to why an atom spontaneously decays in a specified time interval. Our best science tells us that there is literally no 'reason' why an atom decays within a specific time interval. So *assuming that our science is correct*, any reason given will be incorrect. For example, it has been suggested that the apparently indeterministic quantum events in the brain are caused by the operation of 'free will' (Popper and Eccles 1977). Now assume that there is an ontic ground for the decay, but if it is incomprehensible, then any reason relating to free will will be erroneous. Similarly, if there is no comprehensible reason for the fine-tuning then any comprehensible reason based on God is also a necessary explanatory error.

### 8.2.5 *What is the appropriate response to error?*

The appropriate response to error depends on the type of error involved (and whether you know you're in error). First consider contingent explanatory errors. These errors

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<sup>116</sup> This example ignores the complications of relativity theory.

<sup>117</sup> I say *related* because it may be a subclass of either contingent or necessary epistemic error. Alternatively, it may be a distinct category of error.

<sup>118</sup> If our descendants evolve more advanced cognitive systems, then currently necessary explanatory errors may become contingent explanatory errors. But here I am concerned with our cognitive capacity.

relate to comprehensible ontic grounds. The error is due to the fact that although we have the potential to understand the ontic ground our current epistemic reasons are erroneous. Given that the error is contingent, we have the potential to be right, so we should continue looking for the correct epistemic reason. Probabilistic epistemic errors can be considered as a version of contingent epistemic error where we simply have to correct the epistemic probability to match the ontic probability. But the appropriate response to a necessary error is different. If the ontic ground is incomprehensible, then we should not attempt to comprehend it. Our best science suggests that there is literally no reason for spontaneous atomic decay. Any explanation will be necessarily wrong.<sup>119</sup>

### 8.3 Understanding indeterministic explanation

Now focus on the relation between probability and explanation. Mellor captures a central feature of explanation in the following passage.

I think we require explanations to raise the probability of what they explain because we want to know why a state of affairs is a fact when, for all we know, it might not have been. In other words, a principal object of explanation is to close, or at least to reduce, the gap between what we know to be so and what we know to be necessarily so in some not-possibly-not sense. And to have no chance of being otherwise is to be necessary in just such a sense... (Mellor 1995) 75.

If Mellor is correct, we want our explanations to 'raise the probability of what they explain', and ideally to raise the probabilities to 1, or if not 1, then as close to 1 as possible. There are two issues that are relevant here. The first is that the world is not completely deterministic. We may well *want* our explanations to give the events they

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<sup>119</sup> In this thesis I assume that we want our explanations of the fine-tuning to be 'true'. But this is not the only approach to explanation. It may be that truth is not the goal of 'explanation' at all. Consider the distinction between manifest goals and latent functions. The manifest goal of a rain dance is to produce rain. Irrespective of the success of achieving that goal, the rain dance may have the latent function of increasing social cohesion in the community in times of stress (Salmon 1992). We can interpret explanation in a similar way. The manifest goal of explaining the fine-tuning may be truth, but the latent function may be to provide us with *epistemic reasons* that fill the explanatory gap generated by an indeterministic ontic ground. It is epistemically distracting to contemplate the improbability of the fine-tuning of the universe. We can fill this epistemic gap with other universes or with a benevolent creator. Further, there may be a distinct survival advantage (in the form of a positive mental attitude in the face of a hostile world) in believing that we are the loved creation of a benevolent God.

explain probabilities of 1. But in an indeterministic world this is a mistake. Take an indeterministic event with a probability of  $1/2$ . If we choose an explanation that gives this event a probability other than  $1/2$ , we will have fallen into error. This leads on to the second issue, that of the distinction between ontic probability and epistemic probability. I take ontic probabilities to be the probabilities that exist in the world, independent of our understanding of the world. I take epistemic probabilities to be the beliefs we have (generated by our explanations) about probabilities in the world. I take it as uncontroversial that we want our epistemic probabilities to match ontic probabilities.

In a deterministic world the desire that epistemic probabilities match ontic probabilities is consistent with Mellor's intuition that we want explanations to raise the probability of what they explain. In a deterministic world, events that occur have an ontic probability of 1 and events that do not occur have an ontic probability of 0. In this case the motivation for our explanations to raise the epistemic probability of the events they explain ideally up to 1, is reasonable. We may not reach the ideal, but we will not necessarily fall into error by adopting this strategy. However, in an indeterministic world, events that occur may have an ontic probability ranging from 0 to 1. If we want our explanations to raise the epistemic probability of the events they explain ideally up to 1, this is *not* reasonable. In an indeterministic world we should not necessarily want our explanations to raise the epistemic probability of the events they explain.<sup>120</sup>

### *8.3.1 Indeterminism and explanation*

A standard example of indeterminism is radioactive decay. The half-life of Carbon 14 is 5730 years. This means that the probability of any one atom of Carbon 14 decaying in the next 5730 years is  $1/2$  (Salmon et al. 1992) 31. It follows that the decay of this atom *in the next hour* is extremely improbable. Current science accepts this improbability; it does not attempt to 'explain it away'. If the atom decays in the next hour, then current science does not seek some other explanation, perhaps in the form of a hidden variable

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<sup>120</sup> Mellor seems to be aware of this problem. In relation to probabilistic causation he warns that causes must not "*cause* their effects' chances to be higher than they would otherwise be" (Mellor 1995) 67.

that gives the decay a higher probability of occurring. We can learn a great deal from this simple example when we seek to 'explain away' the improbability of the fine-tuning. If the fine-tuning is due to an indeterministic process, then it is simply inappropriate to reject the improbability. I will attempt to explain the fine-tuning not by rejecting the improbability, but rather by accepting it, and arguing that it is the improbable outcome of an indeterministic process. This approach is motivated by the simple observation made by Ian Hacking that "unusual things do occur by chance" (Hacking 1987) 340.

The existence of indeterminism has profound implications for our capacity to *satisfactorily* explain the world and our place in it. I will not undertake a comprehensive analysis of scientific explanation here. But to illustrate the impact of indeterminism consider Carl Hempel's *covering law model* of scientific explanation (Hempel 1965). The basic idea is that an explanation is a deductive or inductive argument with a universal or statistical law of nature as at least one premise. These arguments function as explanations of regularities and particular events associated with universal and statistical laws. There are three basic forms: *deductive nomological* (D-N) explains both regularities and particular events related to universal laws; *deductive statistical* (D-S) explains regularities related to statistical laws; and finally *inductive statistical* (I-S) purports to explain particular events related to statistical laws.

The deductive nomological form is a deductive argument with general laws and antecedent conditions as the premises (the explanans) that lead to the conclusion (the explanandum). This form can explain particular facts or laws, and assumes determinism. But not all explanations rest on exceptionless laws. If we cannot have exceptionless laws, then the next best thing is explanations that yield high probability. For these situations Hempel developed the statistical forms in the covering law model. The deductive statistical form generates the *deductive* explanation of statistical laws from general or universal laws. The inductive statistical form generates the *inductive* explanation of particular facts from statistical laws. This is distinctly different to the D-N and D-S structures in that it is not deterministic, because of the statistical nature of the laws. The strength of the inductive explanation is based on the probability associated

with the statistical law; what Hempel calls the *nomic probability*. A good I-S explanation confers a high probability on the particular event.<sup>121</sup> Thus for Hempel good explanations either give certainty (deductively) or high probability (inductively). But any potential explanation of the decay of a single Carbon 14 atom within a relatively short time interval involves neither certainty nor high probability so, on this model, the explanation is not good.

Richard Jeffrey highlights the problem of explaining improbable indeterministic events (Jeffrey 1969). He considers a fair coin that is tossed twice and lands tails twice. He argues that we understand 'the why and the how' of the outcome just as well as if one head and one tail had been tossed. Further exploring this idea, Chris Hitchcock and Wesley Salmon use the example of a biased coin that has probability 0.1 of landing tails and probability 0.9 of landing heads (Hitchcock and Salmon 2001). Most of the time the coin lands heads, but sometimes it lands tails. They suggest that we understand the coin landing tails *just as much* as landing heads. We can use the biased coin example as an analogy for atomic decay. Assume that an atom has 0.1 probability of decay in a time interval of one hour. So every hour is the equivalent of the coin toss. The coin landing tails is analogous to the atom decaying. Given that we understand the nature of the coin/atom we understand the tails/decay. But this understanding of the tails/decay does not involve certainty or high probability. This illustrates the limit of explaining indeterminism.

There are other standard models of scientific explanation, including the *unification model* (Kitcher 1993), the *causal/mechanical model* (Salmon 1990), and the *pragmatic model* (van Fraassen 1980). I will not consider here how these particular theorists deal with improbable indeterministic events, but I will note two other approaches that attempt to deal with the problem of explaining these events. Peter Railton has proposed a deductive nomological model of probabilistic explanation (D-N-P) (Railton 1978). This explanation has two parts: a deductive argument and a parenthetical addendum. The

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<sup>121</sup> If determinism is true, then the inductive arguments can be considered incomplete deductive arguments.

deductive argument specifies the probability that the indeterministic event will occur and the parenthetic addendum adds the information that the indeterministic event did in fact occur.<sup>122</sup> Secondly, note the *structural explanation* approach suggested by R. I. G. Hughes (Hughes 1989). Prompted by the theoretical challenges posed by Bell's Theorem, Hughes proposes that explanation may be found in the structure of the probability spaces associated with indeterministic events.

### *8.3.2 Explanatory expectations: accepting improbable indeterministic events*

I have presented Mellor's characterisation of explanations as raising the probability of the events they explain. But this may be problematic with respect to improbable indeterministic events. We don't want our explanations to raise the epistemic probability of events above their ontic probability. If the ontic probability is small we want our explanations to reflect that improbability. If indeterminism was involved in the origins of this universe we may need to reconsider our expectations with respect to removing the improbability of the fine-tuning. For the purposes of this thesis I assume that there is indeterminism in the world. I further assume that it can be characterised probabilistically, although not necessarily with the standard probability calculus as it is currently defined. So I assume indeterminism to be a form of objective probability, or ontic probability. I also take it to be reasonable to refer to 'single case' ontic probability. To use the example above, it is reasonable to say that a single atom of Carbon 14 has an ontic probability of decay in the next hour. This atom *may* decay (with a very small probability) or it *may not* decay (with a very large probability) and that is the end of the story. There is nothing further to be said. If the atom decays, then we explain this with reference to the fact that it is Carbon 14. If it does not decay, then we explain this similarly. However, the existence of indeterminism does not sit comfortably with our explanatory preferences. Following Mellor, there is an 'explanatory gap' that we are tempted to fill. However the existence of indeterminism prevents us from doing this. In

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<sup>122</sup> This explanation is presented as an account, comprising an argument and an addendum. Presentation as an account not an argument, avoids the problems associated with arguments leading directly to improbable events.

fact it tempts us to fall into *explanatory error*. Consider the possibility that, rather than simply accepting the decay of the atom in the next hour as an improbable event, we are tempted to postulate the existence of a 'hidden variable' that deterministically caused the decay. This explanation (on the current understanding of indeterminism) is erroneous. There are no hidden variables. The state function is complete (Healey 2001) 377. But how do we ensure that we do not create hidden variables to 'explain away' the improbability?

Alternatively, our explanatory urges may tempt us to choose the wrong explanation. Consider again the decay of the atom of Carbon 14 in the next hour. Imagine that while we sit and watch this very improbable event, we recall that Thorium 234 has a half-life of 24 days. If the atom were Thorium 234, then the decay would be more probable. But while we may have this thought, it is not necessarily a good idea to assume that we must be *mistaken* about the fact that we are watching an atom of Carbon 14. If the idea that we must be mistaken seems like an unlikely response, consider a slightly different presentation of the example. Imagine again a single atom. But this time it is in a box and we don't know if it is Carbon 14 or Thorium 234. In the next hour it decays. Was it carbon or thorium? The orthodox response is to say that it is thorium, *because that is more probable*, but I will argue that this response is not justified. The atom could have either been carbon or thorium. The atom could have been carbon and a very improbable decay event happened to occur. Or it could have been thorium and a less improbable decay event happened to occur. But taken in *isolation* there is literally nothing that can determine which event occurred. The isolated occurrence of an improbable event (the decay of carbon) is *empirically indistinguishable* from the isolated occurrence of a more probable event (the decay of thorium).<sup>123</sup> Now we could *assume* that the most probable event occurred, and thus believe that the atom was thorium, but this is just an assumption. To justify the *conclusion* that a probable event occurred by *assuming* that a probable event occurred is circular. Some argue that such circularity is benign (Lipton

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<sup>123</sup> In this thought experiment we have no information about the products of the decay event; we simply know that an atom decayed.

2000). But when applied to an isolated indeterministic case, it is not benign and can lead to explanatory error.<sup>124</sup>

The central problem here is related to *the problem of the single case*, but not as conventionally understood (Rcsnik 1987) 67. We assume that the single unidentified decaying atom has a well-specified ontic probability of decay in the next hour. So the problem is not that the atom does not *have* a probability of decay, the problem is that we do not know the *value* of the probability. Based on the evidence of the decay of an isolated unidentified atom, there is literally no way to determine the probability of that event. There is a necessary epistemic gap between the knowledge *that* an isolated indeterministic event occurred and the knowledge *of* the ontic probability of that isolated event.<sup>125</sup> The isolated decay could be a probable event (that happened to occur) or it could be an improbable event (that happened to occur). Certainly probable events happen *more often* than improbable events, but in the case of an isolated event, there is no "more often". So rather than call this the problem of the single case, I call it *the problem of the isolated case*.<sup>126</sup>

Similarly the fine-tuning, taken as an isolated event, could be ontically probable or it could be ontically improbable. The fact that the fine-tuning has occurred gives no warrant to assume that it was probable, so we have no warrant to 'explain away' the improbability. This reflects the tension between explanation and indeterminism. We may want explanations to 'raise the probability of the events they explain', but this may be an unrealistic hope, *if our world is fundamentally indeterministic*. We can highlight this gap by considering the distinction between *ontic grounds* and *epistemic reasons*. If

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<sup>124</sup> This leads to a probabilistic version of the problem of induction that we consider later in the thesis.

<sup>125</sup> This highlights the important distinction between epistemic probability as I use the term, and epistemic probability as it is used with reference to subjective probability. 'Epistemic probability' as it is traditionally used, refers to my *confidence* that the event occurred. 'Epistemic probability' as I use the term, relates to my *belief* about the ontic probability of the event.

<sup>126</sup> It is important to note here that neither the principle of direct probability (Hájek 2003) nor Lewis's Principal Principle (Lewis 1986) will help. The principle of direct probability will yield a probability of 1 for any event with a reference class of only itself, and the Principal Principle assumes that we have access to the ontic probability of the event, and that is the one thing we do not have.

indeterminism is a feature of reality, then there will be no 'reasons' that explain certain ontic events, such as the decay of a particular atom at a specific time.<sup>127</sup> We may *want* an epistemic reason for the decay of a particular atom at a specific time. But, on the one hand, if there is no deterministic ontic ground *and* if we generate a deterministic epistemic reason, then we will fall into error. On the other hand, if there is an ontic probability of decay, this may reflect the ontic ground of the decay event. However, if we generate an epistemic probability of the decay event that is *different* from the ontic probability of that event, then we will again fall into error.

#### 8.4 The conformity maxim

The world is, at least in part, indeterministic. We need explanatory strategies that are rich enough to deal with this. Although Mellor suggests that explanations raise the probability of the events they explain, he is aware of the limitation that indeterminism places on our understanding of probabilistic causation.

I shall argue ... that causation's connotations require every cause to raise the chances of its effects. But what does this mean? It must not mean that causes must *cause* their effects' chances to be higher than they would otherwise be. ... What I mean by a cause C raising the chance of an effect E is this: E's chance in the relevant circumstances S with C,  $ch_C(E)$ , is greater than its chance without C,  $ch_{\neg C}(E)$ . In symbols, ...  $ch_C(E) > ch_{\neg C}(E)$ , ... (Mellor 1995) 67.

Mellor's warning that causes must not '*cause* their effects' chances to be higher than they would otherwise be' can be reinterpreted with respect to explanation. The explanans must not give the explanandum more probability that it would otherwise have. Or more precisely, the epistemic probability of an event should not be higher than the event's ontic probability. To illustrate this, I distinguish two types of 'epistemic probability raising': *raising to* the ontic probability and *raising above* the ontic probability. Raising the epistemic probability *to* the ontic probability is epistemically responsible. However raising the epistemic probability *above* the ontic probability is

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<sup>127</sup> Indeterminism requires me to relinquish the principle of sufficient reason.

epistemically irresponsible. So the concept that explanans raise the probability of explananda needs refinement. Explanans should be thought of as *matching* the probability of the explananda. We want our epistemic probabilities implicit in our explanations to match the ontic probabilities in the world. So we can now identify an explanatory maxim based on this notion of conformity; call it *the conformity maxim*.

*Explanans should generate epistemic probability distributions that conform to the ontic probability distributions of the explananda.*

Or

*Explanans should generate hypothetical frequency distributions that conform to the empirical frequency distributions of the explananda.*

This is really only the prescription that theories should conform to the data. But it is important to understand that this prescription is easily overlooked. Given our attempt to explain indeterministic events we cannot ignore the basics. The central point is that the irreducibly statistical nature of the data is due to the ontically probabilistic (indeterministic) nature of the system. If the data is ontically probabilistic we need explanations that generate epistemic probability distributions. We can then choose between competing explanations by considering which epistemic probability distribution best fits the empirical frequency distribution.<sup>128</sup>

#### *8.4.1 The conformity maxim applied*

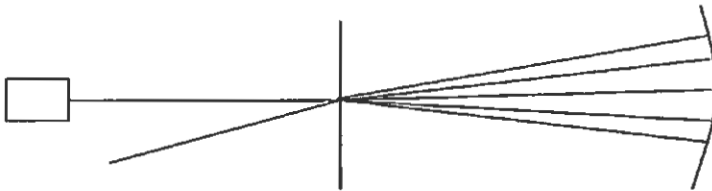
Take the spontaneous decay of an atom. As an indeterministic event, it has a probability of occurring in any finite time interval. Take the event in question to be the decay of this atom in a particular hour. The explanation of this event is simply the specification of the appropriate quantum mechanical system. This specification generates the probability of the atom decaying in the specified time interval. This is based on the uniform probability distribution where the atom has an equal probability of decay in each moment in time.

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<sup>128</sup> Given that these are ontically probabilistic situations we can use a probabilistic analysis to decide which explanation is the best fit. This may correspond to Reichenbach's use of 'higher level' probabilities (Fetzer 1970) 478. Here I am ignoring the problem that there will be an infinite number of competing explanations that all fit the data.

The specification explains the decay. We can test whether the epistemic probability conforms to the ontic probability by comparing the decay of a large sample of radioactive material. If the epistemic probability generated by the explanation conforms to the empirical frequency of decay in the sample, then we have satisfied the conformity maxim.

For a more involved example, consider the scattering experiment suggested by Rutherford and performed by Geiger and Marsden in 1911 (Warren 1983) 74. I chose this example because it involves indeterministic events, although Rutherford did not know of the indeterministic nature of the system at the time. Alpha particles were fired at a thin gold foil and their subsequent trajectories recorded, Figure 8:1.



*Figure 8:1 the Geiger Marsden scattering experiment*

Most of the trajectories of the alpha particles were approximately straight ahead of the emitter, indicating that the particles passed through the gold foil with little deflection. However approximately 1 in 8000 were deflected through angles greater than 90 degrees. We can now interpret the empirical distribution of the alpha particles as the result of an indeterministic system, and consider indeterministic explanations of this situation. So we seek an explanation that generates a hypothetical frequency distribution that matches the empirical frequency distribution of the data. Such an explanation would be based on the indeterministic nature of the atoms in the gold foil and the interaction of these atoms with the alpha particles. This explanation would generate an epistemic probability distribution that would match the ontic probability distribution of deflected alpha particles.

8.4.2 *The advantages of the conformity maxim*

The main advantage is that this maxim works for both deterministic and indeterministic systems. If the system is deterministic, then the ontic probabilities in the probability distribution consist of 0's and one 1. Here the explanation should generate epistemic probabilities of 0's and one 1. Accepting our limited epistemic capacities, we should try to approach these ideal epistemic probabilities. However, if the system is indeterministic, then the ontic probability distribution ranges from 0 to 1. Here the explanation should generate epistemic probabilities that match the ontic probabilities. Another advantage is that this maxim avoids the danger of accepting erroneous explanations that give events epistemic probabilities higher than the event's ontic probability. These errors are avoided because we do not seek to *raise the probability of events unconditionally*. We seek to *match* epistemic probabilities with ontic probabilities. Notice that if our current epistemic probability of an event is *higher* than the ontic probability, then this maxim will prompt us to seek an explanation that *reduces* the epistemic probability of that event. The final advantage relates to situations in which we do not know if the system is deterministic or indeterministic. To be sure, if we know that a system is deterministic, then the unrestrained acceptance of explanations that raise the probability of the event will not necessarily lead to error. However *if we do not know* whether a system is indeterministic or deterministic, then the unrestrained acceptance of explanations that raise the probability of the event may lead to error, and this is epistemically irresponsible. In situations in which we do not know whether the system is indeterministic or deterministic the epistemically responsible course is to use the conformity maxim. If we always seek to match epistemic probability with ontic probability we will not fall into error.

8.4.3 *The disadvantage of the conformity maxim*

Notice the parallel presentation of the maxim in terms of probability and frequency. The only way that we have access to the ontic probability is through empirical frequency.<sup>129</sup> The only way that we can determine whether our epistemic probabilities match the ontic probabilities is by comparing hypothetical frequency (epistemic probability) with empirical frequency'. The most important implication of this disadvantage here is that we cannot determine the ontic probability of isolated events. An isolated event conforms to all hypothetical frequency distributions that specify the event is possible. Put another way, the only way an isolated event does not conform to a hypothetical frequency distribution is if that distribution specifies the event has a probability of 0. This is a significant limitation, but it is unavoidable. The limitation is due to the nature of indeterminism. Take any indeterministic event considered in isolation. This event may be probable or improbable. The fact that it has occurred is not sufficient to determine its probability.<sup>130</sup> When dealing with an isolated ontically probabilistic event we simply cannot determine the probability of that event. This has important implications with respect to choosing between all explanations that generate hypothetical frequency distributions that give the isolated event some probability of occurring. We cannot use the conformity maxim to choose between these explanations.

Thus the conformity maxim has its limits but it deals with difficult territory. The maxim provides a good start in attempting to explain indeterminism. Note that this is not a problem for non-isolated (repeated or repeatable) events. If it is possible to generate (or access) an empirical frequency distribution of the indeterministic events, as was the case in the gold foil example above, then this empirical frequency distribution can be compared with the hypothetical frequency distribution generated by the explanation to

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<sup>129</sup> Here I am not claiming it is *meaningless* to say that an isolated event has an ontic probability. I am simply claiming that we have no way of *determining* the ontic probability of an isolated event.

<sup>130</sup> This is related to the limitation concerning prediction and single case probability statements noticed by (Reichenbach 1949) 371.

see if the two distributions conform. If they do the explanation has potential. If they do not, the explanation has no potential.

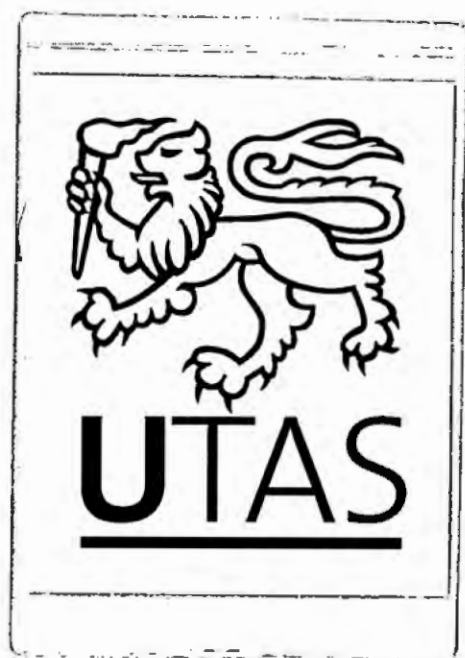
### 8.5 Explaining indeterminism

Mellor has claimed that a principal object of explanation is to remove contingency. But, in an indeterministic world there *is* a chance that the events explained *could have been otherwise* (Salmon et al. 1992) 30. Does this mean that the events have not been explained? If the task of explanation is to remove all contingency, then the events have not been explained. But it is impossible to remove all contingency from an indeterministic world. If quantum indeterminism is accepted, then, at least at the quantum level, the world is "irreducibly statistical". The contingency cannot be removed.

The existence of ontic probability in the form of indeterminism in the world has important implications for explanation. It may be that indeterminism represents an explanatory 'wall' beyond which explanation is not possible. If this is the case, then some events in the world (i.e., the spontaneous radioactive decay of a particle at a specific time) simply lack explanations. But perhaps explanation of specific indeterministic events is possible. This comes down to what we *expect* from an explanation. If we expect explanations to remove contingency, then ontic probability precludes explanation. If we are content for our explanations to incorporate contingency, then ontic probability is compatible with explanation. This distinction can be framed in terms of chance. Perhaps explanation and chance are mutually exclusive; the extent to which something is explained is the extent to which chance is excluded. But this demand on explanation is in tension with the fact that we live in an irreducibly chancy world. It seems that we must reassess our capacity to explain this world.

When considering the strength of an explanation we often take into account how well the explanation deals not only with the *fact* but also with the *foil* (Lipton 2000) 188. We can ask: why did the atom spontaneously decay? And we may be satisfied with an answer involving atomic physics. However, we might also ask: why did the atom spontaneously decay at time  $t^1$  as opposed to time  $t^2$ ? Now answers involving atomic

physics may not satisfy us. While atomic physics may be able to answer the non-contrastive question, it cannot answer the contrastive question. Atomic physics can explain the fact, but it cannot explain the foil. This limitation will have important implications for the fine-tuning debate. If the origin of the fine-tuning is indeterministic perhaps we can explain why the universe has *some* parameter values but we cannot explain why the universe has *these* 'finely-tuned' parameter values.



## 9 Probability and Explanation Choice

### 9.1 Choosing an explanation

#### 9.1.1 *Inference to the best explanation*

*Inference to the best explanation* is one attempt to understand explanation choice. The phrase “inference to the best explanation” is simple, but hides features worth making explicit. A more revealing phrase suggested by Peter Lipton is “inference to the best of the available competing explanations, when the best one is sufficiently good” (Lipton 2000) 187. This highlights that we can only choose from among the available explanations. While we cannot choose an explanation that does not yet exist, we can suspend judgement in the hope that an appropriate explanation is found. Further, the phrasing highlights the fact that we only accept an explanation if it is good enough. The best available explanation may not be good enough. To illustrate this Richard Fumerton considers a lottery of one hundred tickets, in which all participants have one ticket, except you, who have two tickets. While is it reasonable to believe that you have the greatest chance of winning it is not reasonable to believe that you will win. So, if you did win, the fact that you had two tickets is not necessarily a good explanation of why you won. What makes an explanation sufficiently good is an interesting question. Fumerton maintains that to believe an explanation we must believe that it is more likely to be true than the disjunction of all other possible explanations (Fumerton 1992) 208.

Another issue for inference to the best explanation is what ‘best’ means. Following Lipton, the ‘best’ explanation could be the “most probable” or it could be the one that “if correct would provide the greatest degree of understanding” (Lipton 2000) 187. This suggests that the best explanation may balance competing factors. For example, there may be a balance between the *power* and the *simplicity* of an explanation or there may be a balance between the *precision* and the *comprehensibility* of an explanation. Let us consider the precision of an explanation. If we make a very general explanans statement that is consistent with the explanandum, then it is likely that it is true. But it does little to advance understanding. Alternatively, an explanation that is detailed does give us understanding. But the more detailed it gets, the less likely it is to be true. Consider

gravitation. If we explain gravitation as an 'attractive force between massive bodies' we may be correct but this explanation gives little understanding. The explanation is comprehensible but not precise. On the other hand, if we characterise gravity using classical physics then we may well feel that we have a better understanding of gravity. But classical physics is not literally true. The more precise the explanation the more chance it has of being incorrect. Now consider the comprehensibility of an explanation. Imagine an incomprehensible 'explanation' about the world that corresponds well to its empirical features. It may be that the 'explanation' is true. But because it is incomprehensible, it furnishes little understanding. This highlights the potential tension between comprehension and truth. If we explain the world using comprehensible concepts, then this may furnish a sense of understanding, but just because an explanation is comprehensible does not mean that it is true. Our 'understanding' of the world *by definition* must be comprehensible, but this does not imply that the world itself is comprehensible. An 'explanation' that we find intellectually satisfying may literally be false. For example, indeterminism might be true, but it does not necessarily furnish understanding. Alternatively, while it may be false that God exists, arguably God furnishes 'understanding'. So we must be careful that inferences to the 'best explanation' do not lead away from the truth.

### *9.1.2 Self-evidencing explanation*

Leslie relies on the notion of self-evidencing explanation as a basis for his *neatness principle* that is, as he notes, a version of confirmation theory.

A chief reason for thinking that something stands in special need of explanation is that we actually glimpse some tidy way in which it might be explained.

This is just one aspect of the point – fundamental to all science and formalized in Bayes's rule of the calculus of probabilities – that observations improve your reasons for accepting some hypothesis when its truth would have made those observations more likely (Leslie 1989) 121.

The central idea of self-evidencing explanations is that the explained phenomenon itself provides essential support for the belief that the explanation is correct (Lipton 2000)

185. Lipton identifies a "curious circularity" associated with such explanations,

whereby the "hypotheses are supported by the very observations they are supposed to explain" (Lipton 2000) 185. Lipton considers this circularity benign but this circularity is not benign when we are considering *isolated* ontically probabilistic events. I will argue that it is not reasonable to choose an explanation for a isolated ontically probabilistic event based only on the fact that the explanation would make that event more probable.

### *9.1.3 Confirmation theory*

Probability plays a central role in how we choose between explanations. Imagine that we are walking in the wilderness and we come upon a number of stones on the ground such that they form a circle. One explanation is that their locations are due to some *non-human* process. Another is that their position is due to some *human* process. Which of these two explanations should we choose? Of course, we could decide not to choose, we could suspend belief. But assume that we have some good reason to make a choice. So what do we choose to believe? I assume that we want to believe the true one. But how do we decide which is true? We could use probability to help make our decision.

In deciding between these two explanations we might consider the probability of the creation of a stone circle *conditional* on each processes. The probability of the creation of a stone circle might be quite low if it were due to a non-human process, while it might be quite high if it were due to a human process. Here we are considering the *probability of the stone circle* conditional on the competing processes. We may also consider the *probability of the processes themselves*. We would consider the *unconditional* probability of the existence of a non-human process that could have caused the stone circle and compare this to the *unconditional* probability of the existence of a human process that could have caused it. Here we are using epistemic probability to help decide between competing explanations. The role of probability in explanation in the two senses, namely the probability of the explanation *itself*, and the probability of the evidence *conditional* on the explanation have been formalized in confirmation theory.

The following basic outline of confirmation theory is drawn from (Swinburne 1973, 1991). The fundamental concept is that probabilistic relations exist between statements,

propositions or beliefs. For instance, if we hold a certain proposition to be true then that belief may affect our belief in the probability of the truth of another proposition. The probability here is to be interpreted as 'inductive probability'.<sup>131</sup> The various statements, propositions and beliefs that have these probabilistic relations can be considered as either hypotheses or evidence and Swinburne further divides evidence into new evidence and background knowledge.<sup>132</sup>

A hypothesis may increase the inductive probability of certain evidence and similarly evidence may increase the inductive probability of a hypothesis. In such cases the hypothesis is said to 'explain' the evidence and the evidence is said to 'confirm' the hypothesis.<sup>133</sup> A hypothesis explains the evidence, when the probability of the evidence given the hypothesis, is greater than the prior probability of the evidence.<sup>134</sup> Evidence confirms a hypothesis when the probability of the hypothesis, given the evidence, is greater than the prior probability of the hypothesis. In symbolic form these relations can be expressed as follows.

$$P(e/h.k) > P(e/k)$$

*The probability of the evidence given the hypothesis and background knowledge is greater than the prior probability of the evidence.*

and

$$P(h/e.k) > P(h/k)$$

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<sup>131</sup> The term 'inductive probability' is taken from (Swinburne 2004) 14. Previously, Swinburne (Swinburne 1973, 1991) has used the term 'epistemic probability' and he equates this with Carnap's 'probability', (Carnap 1950). However, I will not use Swinburne's phrase 'epistemic probability' here because it will be easily confused with my different usage of the same phrase.

<sup>132</sup> Swinburne notes that it is possible to move distinct parts of evidence between 'new evidence' and 'background knowledge' and these movements will affect the probability of the hypothesis.

<sup>133</sup> Here the use of the term 'explain' is being used in a specific 'probability raising' sense.

<sup>134</sup> Prior probability is the probability of a proposition, independent of the other proposition being considered.

*The probability of the hypothesis given the new evidence and background knowledge is greater than the prior probability of the hypothesis.*

These two probabilistic relations are fundamental to confirmation theory and are the basis of the following inference.

*Since  $P(e/h.k) > P(e/k)$  therefore  $P(h/e.k) > P(h/k)$ .*

*Since the probability of the evidence given the hypothesis and background knowledge is greater than the prior probability of the evidence therefore the probability of the hypothesis given the evidence and background knowledge is greater than the prior probability of the hypothesis.*

In other words, since the hypothesis explains the evidence, therefore the evidence confirms the hypothesis. This inference is derived from the simplest form of Bayes' Theorem:

$$\frac{P(h/e.k) = P(h/k) \times P(e/h.k)}{P(e/k)} \quad \text{Dividing both sides by } P(h/k)$$

Yields 
$$\frac{P(h/e.k)}{P(h/k)} = \frac{P(e/h.k)}{P(e/k)}$$

And this implies,  $P(h/e.k) > P(h/k)$  iff  $P(e/h.k) > P(e/k)$  which has been called by J. L. Mackie the *relevance criterion* (Mackie 1969) and is equivalent to the inference central to confirmation theory presented above.

#### 9.1.4 Confirmation theory and competing hypotheses

Confirmation Theory can be used to compare competing hypotheses. In such cases a comparison is made between the prior probabilities of the competing hypotheses and a further comparison is made between the probabilities of the evidence given the different hypotheses. These two comparisons determine the relative probability of the competing hypotheses. (Discrete numerical probabilities are not required - many comparisons in confirmation theory simply involve deciding whether one probability is higher or lower than another without either having a discrete numerical value.) For the purpose of this analysis, assume that the prior probabilities of the competing hypotheses are equal

$(P(h_1, k) = P(h_2, k))$  and further assume that the probability of the evidence given hypothesis  $h_1$  is greater than its probability given hypothesis  $h_2$ :

$$P(e/h_1, k) > P(e/h_2, k)$$

Then using the relevance criterion:

$$\text{Since } P(e/h_1, k) > P(e/h_2, k) \text{ therefore } P(h_1/e, k) > P(h_2/e, k)$$

Given hypothesis  $h_1$  makes the evidence more probable than hypothesis  $h_2$ , then confirmation theory tells us that hypothesis  $h_1$  is more likely. In other words, since the hypothesis  $h_1$  explains the evidence better than hypothesis  $h_2$  therefore the evidence confirms hypothesis  $h_1$  more than it confirms hypothesis  $h_2$ .

## **9.2 Indeterminism and confirmation**

### *9.2.1 A problem for confirmation theory*

Confirmation theory requires that we increase the inductive probability of a hypothesis because that hypothesis makes our evidence more probable. On first impressions this seems an intuitively sound strategy.<sup>135</sup> But there is a problem in the case of isolated indeterministic events.

Before we look at this problem itself I would like to make some brief comments about the motivation for this analysis. My aim is to highlight a problem with the application of confirmation theory to the fine-tuning. I intend to demonstrate that confirmation theory leads us into error. Later I will compare two competing hypotheses in relation to the origin of the fine-tuning: chance and design. I will argue that the mere fact that the evidence of the fine-tuning is more probable given the design hypothesis than given the chance hypothesis gives us no justification for thereby assigning more probability to the design hypothesis than to the chance hypothesis. This problem, I believe, is directly related to the fact that the fine-tuning of the universe may be an isolated indeterministic

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<sup>135</sup> Note the similarity to Mellor's observation, that we want our explanations to raise the probability of what they explain.

event. (The fine-tuning is an isolated event because we have no knowledge of other universes, and our best science suggests that the fine-tuning may have been set indeterministically.)

Now I wish to explore the general problem of confirmation with respect to an isolated indeterministic event. In order to do this I will use examples other than the fine-tuning. However there is a problem with this approach. Finding examples of truly isolated indeterministic events is difficult. In fact the universe itself may be the only truly isolated event.<sup>136</sup> So, as we will see, the examples used are not really isolated events. Thus it will be necessary to imagine these events (that are clearly not isolated) as isolated events for the purposes of argument.

Furthermore, when considering these examples, I will assume that the prior probabilities of the competing hypotheses are equal. I set the priors equal for a specific reason. I want to make explicit the role of the relevance criterion within confirmation theory. Holding the priors equal will mean that any differential probability that results from the application of confirmation theory will be due solely to the functioning of the relevance criterion. (Later, with reference to the fine-tuning, I will assume that it is not unreasonable to grant equal prior probability to the competing hypotheses of chance and design, simply because of the absence of any uncontested background knowledge.<sup>137</sup>) Unfortunately this technique of holding the priors equal will seem very odd within the examples used here. I want to stress that I am not claiming to show anything definitive with respect to the examples themselves (because they are not truly isolated events). I am simply using the examples to illustrate the problem; the problem I will later examine with reference to the fine-tuning.

Before I begin I need to clarify my use of the term epistemic probability. Epistemic probability generally refers to degrees of belief or *confidence* in the facts. Consider an

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<sup>136</sup> For the purposes of this analysis I am assuming that the universe can be considered as an event.

<sup>137</sup> Here I am ignoring all other possible competing hypotheses and distributing the total prior probability equally between design in the form of theism and chance in the form of indeterminism.

example due to Mellor; I can watch a coin *appear* to land on its edge and I can have a certain confidence, based on the lighting, my eyesight, etc., that it did *in fact* land on edge (Mellor 2003) 224. I might hold an epistemic probability (in the sense of confidence) of 50% that the coin landed on its edge. However throughout this discussion I will use a different concept of epistemic probability, independent of confidence. I use the term 'epistemic probability' to refer to probabilistic beliefs that exist in my mind *about* ontic probabilities in the world. I want my beliefs about the probabilities in the world to match the actual probabilities 'out there'. I want my epistemic probabilities to match ontic probabilities. For example if a die has an ontic probability of 1/6 of landing '3' then I want my epistemic probability, that the die will land '3' on any particular role, to be 1/6. But, for the purposes of this discussion, I am not interested in my confidence that the die did in fact land '3' on any particular roll.

I assume that the avoidance of explanatory error is epistemically responsible. We do not want our explanans to raise the *epistemic* probability of the explananda above its *ontic* probability. However the unrestrained application of confirmation theory risks the acceptance of explanations that raise the epistemic probability of events above their ontic probability. So now let us look at this problem in more detail.

Confirmation theory gives us the following relation:

$$\text{If } P(h_1/k) = P(h_2/k) \text{ then } P(h_1/e.k) > P(h_2/e.k) \text{ iff } P(e/h_1.k) > P(e/h_2.k)$$

Thus, when  $P(h_1/k) = P(h_2/k)$  it follows that;

$$\text{Since } P(e/h_1.k) > P(e/h_2.k) \text{ therefore } P(h_1/e.k) > P(h_2/e.k)$$

I argue that this confirming relation should not necessarily have inductive force in the case of isolated indeterministic events. I will argue that simply because a hypothesis makes the evidence more probable, this is not necessarily a good reason to believe the hypothesis more likely to be true.

As mentioned above, throughout this analysis I assume that the prior probabilities of the competing hypotheses are equal:  $P(h_1/k) = P(h_2/k)$ . This may be unrealistic in these examples, but I do this to make the problem more apparent. For example, any

pronounced inequality of priors may avoid the final conclusion that one hypothesis is more probable than another other, even after conditionalization that increases the probability of the less probable hypothesis. But in this analysis I want to remove the confounding effect of the priors.

So, with that said consider the example of a lottery.

*Background knowledge*       $k$  - There is a lottery (L).

*Evidence*       $e$  - Someone wins (W).

*Hypothesis one*       $h_1$  - The lottery was rigged for *that* someone to win (R).

*Hypothesis two*       $h_2$  - The lottery win was fair (F).

Assuming the prior probabilities of the hypotheses are equal ( $P(R/L) = P(F/L)$ ), compare the probability that someone wins conditional on the lottery being fair with the probability conditional on the lottery being rigged in favour of *that* someone. Clearly the probability that someone wins if the lottery is rigged *in their* favour is greater than if the lottery is fair. The relevance criterion implies that the probability of the lottery being rigged is now greater than the probability that the lottery was fair.

$$P(R/W.L) > P(F/W.L) \text{ iff } P(W/R.L) > P(W/F.L)$$

$$\text{Since } P(W/R.L) > P(W/F.L) \text{ therefore } P(R/W.L) > P(F/W.L)$$

By this rule, *whoever* won seems compelled to conclude that the lottery was rigged in their favour. This is a problem. Of course one might argue that the priors are not equal, because presumably we have seen many fair lotteries and few rigged ones, but this does not remove the force of the criticism. The weight of the priors may well avoid the final conclusion that the rigged hypothesis is more likely than the fair hypothesis but this is not my point. Imagine that this lottery is a truly isolated indeterministic event and that the priors are equal. I claim that the fact that a certain person won should support both hypotheses equally. There should be no differential confirmation between the two hypotheses. If confirmation theory prompts us to believe that the evidence supports one

hypothesis more than the other, then confirmation theory leads to error.

Consider another example, a single roll of a die.

*Background knowledge*       $k$  – A die is rolled (R).

*Evidence*       $e$  – The die rolls '3' (3).

*Hypothesis one*       $h_1$  – The die is loaded to roll '3' (L).

*Hypothesis two*       $h_2$  – The die is fair (F).

Again assume that the prior probabilities of the fair and loaded hypotheses are equal ( $P(L/R) = P(F/R)$ ).<sup>138</sup> Now consider the conditional probabilities. The probability that the die rolls '3', conditional on the fact that the die is loaded to roll '3', is greater than the probability that the die rolls '3' conditional on the fact that the die is fair:  $P(3/L.R) > P(3/F.R)$ . From this confirmation theory prompts us to believe that the probability of the load hypothesis is greater than the fair hypothesis.

$P(L/3.R) > P(F/3.R)$  iff  $P(3/L.R) > P(3/F.R)$

Since  $P(3/L.R) > P(3/F.R)$  therefore  $P(L/3.R) > P(F/3.R)$

By this rule we should infer that the die is loaded to roll whatever face lands uppermost. This is erroneous. Again one might protest that the priors are not equal, given our experiences of dice, but again this does not affect the force of my argument. Again imagine that this roll is a truly isolated indeterministic event. I claim that the fact that a die rolls '3' should support both hypotheses equally. If confirmation theory prompts us to believe that the evidence supports one hypothesis more than the other, then confirmation theory leads to error.

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<sup>138</sup> Again I am ignoring all other possible hypotheses, such as the die being loaded to roll some other number, and distributing the total prior probability equally between the two hypotheses being considered.

Consider a gambler, who walks into a room, observes one roll of a die and then leaves again.<sup>139</sup> (This gambler happens to believe that the prior probabilities of the die being loaded to land 3, and being fair are equal.) The roll was a '3'. Is it reasonable for the gambler to infer that the die was loaded to land 3? This conclusion seems intuitively unwise, but this is exactly what confirmation theory demands. In response to this demand Jeffrey's point comes to mind - we understand the improbable outcome of a chance event, just as much as we understand the probable outcome (Jeffrey 1969) 109. Jeffrey's point reminds us that improbable things happen, *sometimes*.

Now consider some examples specifically involving indeterminism that get us closer to the heart of the problem. The first relates to hidden variables and atomic decay.

*Background knowledge*       $k$  - Atoms decay ( $A$ ).

*Evidence*       $e$  - An atom decays at a particular time ( $D$ ).

*Hypothesis One*       $h_1$  - A hidden variable caused the decay ( $HV$ ).

*Hypothesis Two*       $h_2$  - The decay is indeterministic ( $I$ ).

Again assume that the prior probabilities of the quantum mechanical and hidden variable hypotheses are equal ( $P(I/A) = P(HV/A)$ ), and consider the conditional probabilities. The probability that the atom decays at a particular time conditional on the fact that a hidden variable caused the decay at that time, is greater than the probability that the atom decayed at that particular time conditional on the fact that quantum mechanics 'caused' the decay:  $P(D/HV.A) > P(D/I.A)$ .

Using the relation,  $P(h_1/e.k) > P(h_2/e.k)$  iff  $P(e/h_1.k) > P(e/h_2.k)$

$P(HV/D.A) > P(I/D.A)$  iff  $P(D/HV.A) > P(D/I.A)$

Since  $P(D/HV.A) > P(D/I.A)$  therefore  $P(HV/D.A) > P(I/D.A)$

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<sup>139</sup> This example is a variation of Hacking's illustration of the Inverse Gamblers Fallacy (Hacking 1987).

Here confirmation theory prompts us to believe that the probability of the hidden variable hypothesis is greater than the quantum mechanical hypothesis. Again one might protest, given Bell experiments (Mermin 1985) 45, that the priors are not equal, but again this does not affect the force of the argument. Again, consider this as an isolated event. I argue that the fact that the atom decayed at a particular time should support both hypotheses equally. If confirmation theory prompts us to believe that the evidence supports one hypothesis more than the other, then confirmation theory leads to error. Notice here that confirmation theory leads us away from the currently well-regarded conclusion that there are no hidden variables associated with these events (Sklar 1995) 291.

The next example is the thought experiment we have previously considered involving a single unidentified atom in a box. The atom is either Carbon 14 (with a half-life of 5730 years), or Thorium 234 (with a half-life of 24 days), and we have no reason to believe it is one rather than the other, so  $P(T/A) = P(C/A)$ . During the next hour the atom decays; was it Carbon 14 or Thorium 234?

<i>Background Knowledge</i>	$k$	There is one atom in a box (A).
<i>Evidence</i>	$e$	The atom in the box decays (D).
<i>Hypothesis One</i>	$h_1$	the atom was Thorium 234 (T).
<i>Hypothesis Two</i>	$h_2$	the atom was Carbon 14 (C).

Considering the conditional probabilities, the probability that the atom decayed, given that it was Thorium 234, is greater than the probability that it decayed, given that it was Carbon 14.

$$P(h_1/e.k) > P(h_2/e.k) \text{ iff } P(e/h_1.k) > P(e/h_2.k)$$

Since  $P(D/T.A) > P(D/C.A)$  therefore  $P(T/D.A) > P(C/D.A)$

The hypothesis that the atom was Thorium 234 is confirmed in this situation. But this is a mistake. The fact that one event is more probable than another event is no reason to

conclude that the probable event occurred. This mistake relates to the tension between the *asymmetry* of indeterministic systems and the *symmetry* of the calculus. The symmetry of the calculus is expressed in the equation we derived above from the simple form of Bayes' Theorem:

$$\frac{P(h/e.k)}{P(h/k)} = \frac{P(e/h.k)}{P(e/k)}$$

The symmetry is also expressed in the form of the relevance criterion with respect to competing hypotheses:

$$\text{If } P(h_1/k) = P(h_2/k) \text{ then } P(h_1/e.k) > P(h_2/e.k) \text{ iff } P(e/h_1.k) > P(e/h_2.k)$$

This symmetry demands that if a hypothesis makes a particular event more probable than the competing hypothesis, then the occurrence of that event thereby makes the hypothesis more probable than the competing hypothesis (when the hypotheses have equal prior probability).

But the symmetry of the calculus is not shared by indeterministic systems. Indeed the tension mentioned above is due to the fact that the ontic probability at work within indeterministic systems does not conform to the calculus. The fact that the atom is a radioactive isotope gives it a probability of decay. But the fact that it decayed does not give it an ontic probability of having been Carbon 14 or Thorium 234.<sup>140</sup> This is Humphreys' Paradox (Humphreys 1985). This paradox is usually presented as a problem for the propensity interpretation of probability. But regardless of whether indeterminism can be considered probabilistically there is another problem relating to the application of the inductive probabilities of confirmation theory to this indeterministic situation. If we use inductive probability to reason about indeterministic systems we may be led into error. So quite apart from the fact that we cannot *understand* the decayed atom having a propensity to have been either of Carbon 14 or Thorium 234, we cannot *conclude* that the decayed atom was Thorium 234 simply because, if it was, then the decay would have

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<sup>140</sup> This is a variation of an example used by Phil Dowe (personal communication).

been more probable. So in addition to Humphreys' Paradox, I contend that the fact that the atom decayed should give it no more inductive probability of being Thorium 234 than of being Carbon 14.

Now consider an example taken from statistical mechanics. Imagine a block of ice placed in warm water, and after some time, the block of ice is larger and the water warmer. Again imagine that this is an isolated situation. This may seem a strange example but it should be noted that this event is completely consistent with the fundamental dynamical laws (Loewer 2001) 611.

<i>Background knowledge</i>	$k$	a block of ice is placed in warm water (iw).
<i>Evidence</i>	$e$	the block of ice is larger & the water warmer (IW).
<i>Hypothesis one</i>	$h_1$	the law of 'anti-thermodynamics' holds (A).
<i>Hypothesis two</i>	$h_2$	the 2 <sup>nd</sup> law of thermodynamics holds (T).

Again assume that the prior probabilities of the law of 'anti-thermodynamics' hypothesis and the 2<sup>nd</sup> law of thermodynamics hypothesis are equal ( $P(A/iw) = P(T/iw)$ ), and consider the conditional probabilities: the probability that the ice block increases in size is greater given the law of 'anti-thermodynamics' than given the 2<sup>nd</sup> law of thermodynamics.

Using the relation:  $P(h_1/e.k) > P(h_2/e.k)$  iff  $P(e/h_1.k) > P(e/h_2.k)$

Since  $P(e/h_1.k) > P(e/h_2.k)$  therefore  $P(h_1/e.k) > P(h_2/e.k)$

Since  $P(IW/A.iw) > P(IW/T.iw)$  therefore  $P(A/IW.iw) > P(T/IW.iw)$

Confirmation theory prompts us to assign more probability to the 'anti-thermodynamic' hypothesis. Thus the law of 'anti-thermodynamics' is confirmed by this evidence. I maintain that this is a mistake. Now I should stress some important points here. The first is that the event of the ice block getting larger is completely consistent with fundamental dynamical laws.

There are microstates consistent with fundamental dynamical laws that are compatible with both thermodynamic and anti-thermodynamic behaviour. For example, there are microstates that realise a block of ice in warm water which the dynamical laws evolve into states in which the ice has melted and the water is at uniform temperature. But there are other microstates that realise a block of ice in warm water which the laws evolve into states which realise a larger block of ice in warmer water! The usual statistical mechanical explanation of why every block of ice we encounter behaves in the first way and we never encounter a block of ice that behaves in the second way is that the probability of a microstate that evolves in the first way is vastly greater than the probability of a microstate that behaves in the second (Loewer 2001) 611.

So here we have an event that is completely consistent with the fundamental dynamical laws, but according to confirmation theory this event disconfirms thermodynamics. I claim that something has gone wrong. The problem is that isolated indeterministic events are not amenable to the central probabilistic inference of confirmation theory. Indeterministic systems generate improbable events, so naturally these events are *consistent* with the indeterministic system. But using confirmation theory we are prompted to disconfirm a hypothesis when events occur that are improbable given that hypothesis. This highlights the fact that confirmation theory seems to implicitly assume physical determinism. However modern science has moved away from determinism.

When originally formulated in the mid-nineteenth century, the second law of thermodynamics was thought of as an exceptionless principle, on par with the other laws of physics. As statistical approaches to thermodynamics developed, however, it came to be realized that the principles they implied would have a different character. ...

Violations of statistical principles based on the average movement of vast numbers of particles might be highly unlikely, but they were not impossible. Far from excluding them, in fact, the statistical treatment underwrote their physical possibility (Price 1996) 27-28.

So the issue is how to deal with the incompatibility of indeterminism and confirmation theory. A response that can be made here is that just one *isolated* piece of evidence is never used to determine the truth of a hypothesis. But this response relies on a methodological limit. We may well take other evidence into account, in the form of the prior probabilities of hypotheses, when we make our final decision. However that is not my main point. I claim that the symmetrical nature of the calculus has already led to

error. The symmetry, in the form of the relevance criterion, requires that we assign more epistemic probability to that hypothesis which gives the evidence more probability. This is the error. In an indeterministic world we simply cannot make a simple probabilistic inference from the probability of an isolated event to the probability of the cause of that event. The problem here seems to be related to two aspects of the process. The first aspect involves the relation between ontic probability (indeterminism), epistemic probability, and the probability calculus. The second aspect relates to the consideration of the probability of isolated indeterministic events. These two aspects are themselves related but it is useful to consider the two aspects separately.

### *9.2.2 Indeterminism, determinism, ontic probability and epistemic probability*

Confirmation theory uses inductive probability, which is a type of epistemic probability. The use of confirmation theory leads to erroneous epistemic probabilities. But we want our epistemic probabilities to accurately map ontic probabilities. Confirmation theory prescribes that we assign more epistemic probability to the hypothesis that gives the evidence more probability. But this is in direct tension with indeterminism. Here I assume that indeterminism implies that certain events can be ontically improbable. Now, some claim that it is inappropriate to interpret quantum indeterminism as probabilistic, and I consider this shortly. However, assume here that we can characterise indeterminism as ontically probabilistic. If an event is ontically improbable, then we do not want to accept a hypothesis that gives the event more epistemic probability than its ontic probability. But confirmation theory leads to this error.

Why does confirmation theory lead us to accept hypotheses that raise the probability of the evidence? The technical reason is the symmetrical structure of the probability calculus. But in addition, I hold that the problem relates to an implicit assumption within our explanatory processes: the assumption that the world is deterministic. I cannot explain how this is implicit in the probability calculus, but it seems that the very structure of the calculus assumes that the world is deterministic, and further, the calculus seems to imply that the only probabilities are epistemic probabilities. This would certainly explain why it is 'good' to accept hypotheses that raise the probability of the

evidence.

There are four potential solutions to this problem: (1) reject indeterminism; (2) claim that indeterminism cannot be analysed probabilistically; (3) reject the symmetrical nature of the probability calculus; (4) limit the application of the probability calculus with respect to isolated indeterministic events. I consider each of these in turn.

The first option is to reject indeterminism. But modern science strongly supports it (Sklar 1995). So I assume this is not an attractive option. The second option is to deny that indeterminism can be analysed probabilistically. The propensity interpretation of probability was developed by Karl Popper to deal with single case physical probabilities, so this seems the most appropriate interpretation to apply to indeterministic systems. However, there are problems with the propensity interpretation (Eagle 2004). The relevant problem here is Humphreys' Paradox (Humphreys 1985). It is understandable that an indeterministic system generates ontic probabilities for the occurrence of certain events. However, the symmetrical nature of the calculus allows for the calculation of the inverse 'ontic probability' that an event was caused by a certain indeterministic system. This must be interpreted as an event having propensities to have been caused by different indeterministic systems (Salmon et al. 1992) 80. While this can be understood as an epistemic probability, it cannot be understood ontically. Events either have or do not have a causal relation with any particular cause. They do not have ontic probabilities of having been caused by a range of different causes.

Humphreys' Paradox highlights the tension between epistemic and ontic probability. Confirmation theory works well if we are only dealing with epistemic probabilities in a deterministic world. Then it is reasonable to assign more epistemic probability to hypotheses that give events more epistemic probability. But this confirming relation breaks down when applied to isolated events in an indeterministic system. It is a mistake to hold that an indeterministic system that gives an event a small probability is somehow 'disconfirmed' by the occurrence of that event. This is because the symmetrical relation in the probability calculus does not hold for ontically probabilistic systems. The occurrence of ontically improbable events does not reduce the ontic probability that they were caused by a particular indeterministic system, just as the occurrence of

ontically probable events does not increase the ontic probability that they were caused by a particular indeterministic system.<sup>141</sup>

The language used in confirmation theory further highlights the tension between epistemic probability and ontic probability. This theory concerns the probabilistic relation between 'hypotheses' and 'evidence'. These terms are clearly epistemic terms, and when the probabilities are interpreted as epistemic there is no difficulty in understanding that hypotheses have a probability of being true. While the calculus supports the symmetric relation between the *epistemic* probability of the evidence and the hypothesis, this symmetric relation does not hold for *ontic* probability.

Indeterministic events have ontic probabilities. However the ontic probability of an event does not have an equivalent symmetric relation with the ontic probability (if there is such a thing) of the reality of the indeterministic system that caused that event. Given the standard interpretation of the relation between cause and effect, the effect has an ontic probability of occurring, but the cause does not have an ontic probability of having been the cause. The 'cause' either was, or was not the cause of the effect.<sup>142</sup>

The second response, to deny that indeterminism can be characterised probabilistically, is not a good option. Probability theory is now central to both quantum theory and statistical mechanics. However, even if we could extract probability theory from modern physics, there is another problem. The 'probability' associated with indeterminism is asymmetric (as illustrated by Humphreys' Paradox), but the probability associated with confirmation theory is 'symmetric' (as illustrated by the relevance criterion). If we continue to use a symmetric probability calculus without restraint to reason about an asymmetric system, such as any indeterministic system, we will continue to be led into error. So denying that indeterministic systems are probabilistic will not help, because the problem relates to the application of symmetric epistemic probability to an asymmetric system.

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<sup>141</sup> If this phrase is meaningful at all, then 'the ontic probability that they were caused' can only be 0 or 1.

<sup>142</sup> Here we should not be distracted by the concept of partial causes. Again, partial causes either were or were not partial causes.

This leads to the third option. The symmetrical nature of the probability calculus leads to error. So this option is to reaxiomatize the calculus to avoid this symmetry. Although there are alternate axiomatizations (Roeper and Leblanc 1999), I am unaware of any that avoid the fundamental symmetrical form causing the problem. It may be possible to construct an asymmetrical mathematical structure that sits more easily with the realities of indeterministic systems, but then it may not be a 'calculus' in the fundamental sense of the word, meaning 'a method of calculation'. It is unclear to me how an asymmetric mathematical structure could be used to calculate the 'probability' of an indeterministic system from the 'probability' of an indeterministic event caused by that system. Again it is the notion of the *ontic probability* of the indeterministic cause that is the problem. The ontic probability of indeterministic events does not have the same probabilistic relation with the indeterministic system itself that the epistemic probability of an effect has with the epistemic probability of its hypothetical cause. And even if it were possible to reaxiomatize the calculus in such a way as to address these concerns, there may still be a problem. Imagine that we have a new axiomatization that works for indeterministic systems; then unless we give up on the current calculus for epistemic probability, we would have two parallel axiomatizations: one for epistemic probability and another for ontic probability. These two would work in the realms for which they are designed, but they may be incommensurable, meaning that probabilities in one are not translatable into probabilities in the other. If so, we are left with the original problem that the probabilistic processes of confirmation theory cannot be used to make inferences concerning isolated events generated by indeterministic systems.

The fourth option is to limit the application of confirmation theory in indeterministic systems. The central problem is that an isolated event can either be a probable event given one hypothesis, or an improbable event given another hypothesis. However the occurrence of the isolated event does not help determine which of these hypotheses is correct, because the occurrence of the isolated event is consistent with both hypotheses. This problem may only relate to isolated events. If this is the case, then we may be able to solve the problem by limiting the use of confirmation theory with respect to isolated events. If this limitation works, then we have a simple solution that causes minimum

disruption to our epistemic processes and so we will not require the more extreme options considered above.

### *9.2.3 The limitation of confirmation theory in dealing with isolated events*

I contend that the problem relates to the application of confirmation theory to isolated events. Confirmation theory assigns greater epistemic probability to the hypothesis that gives the event greater probability. This approach presupposes that the event is ontically probable. But the event may be ontically improbable. If the event is ontically improbable confirmation theory has led to error. An isolated event may be ontically probable or ontically improbable and there is no way to determine which from the event's *isolated* occurrence. To illustrate this, consider two hypotheses associated with an isolated event. On one hypothesis the event is probable (and happened to occur), on the other it is improbable (and happened to occur). However, based on the evidence, these hypotheses are *empirically indistinguishable*. Nothing about the isolated occurrence of an event can tell us the ontic probability of that event. The only way to determine the ontic probability is by considering the event in the context of other events.

Recall the examples above, and consider the possibility that the problem lies in the application of confirmation theory to isolated events. Take the lottery. Confirmation theory prompted us to believe that the lottery was rigged because this made the win more probable. But on the other hand someone had to win, even if that win was an improbable outcome. After all we know that improbable things happen. The question is, should we believe the lottery was rigged or not? We want to believe the truth. The fact of the matter is that the lottery was either rigged or it was fair. The fact that the win would be *more probable* if the lottery were rigged does not *make* the lottery rigged. The evidence before us, the single event of the win, might be a probable event that happened (because it was rigged) or an improbable event that happened (because it was fair). We do not have enough evidence to distinguish the hypotheses. The only way to decide is to see more lotteries, but then we are not talking about other lotteries, we are talking about this lottery.

Or consider the atom in the box. If the atom were an atom of Thorium 234 the decay

would be more probable than if it was an atom of Carbon 14. Confirmation Theory thus prompts us to believe that the atom is Thorium 234. But on the other hand atoms of Carbon 14 also decay. What if the atom was an atom of Carbon 14 and it just happened to decay? After all improbable things do happen. It is as if there is an implicit assumption in our epistemic processes that says "assume the things we see are probable events". But this does not seem reasonable in an indeterministic world.

This idea that we implicitly assume that the events we see are probable events is brought into stark relief when we consider the last example of the ice block in warm water. As noted, the ice block getting larger is completely consistent with the dynamical laws. The only reason we do not expect to see an ice block getting larger is because it is very improbable. But if we did see it, confirmation theory would prompt us to interpret this evidence as disconfirming the dynamical laws. This is a mistake. The mistake relates to the fact that the evidence actually supports both hypotheses equally, but the application of confirmation theory to isolated events does not reflect this.

The application of confirmation theory to isolated indeterministic events is not reasonable. An event taken in isolation can be either probable on one hypothesis, or improbable on another hypothesis. But 'probable' does not mean *ontically necessary* and 'improbable' does not mean *ontically impossible*. (Unless of course we are assuming that epistemic probability is an attempt to approach the limits of 0 and 1 of the ontic probabilities in a deterministic world.) Improbable events happen and probable events happen. To be sure, improbable events do not happen often, but they do happen sometimes.<sup>143</sup> Confirmation theory relies on the implicit notion that more probable events happen *more often* than less probable events. This is uncontroversial. But improbable events can and do happen. However if an event is improbable, then it will not happen *often*. If an event is probable, then it will happen often. But in the case of an

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<sup>143</sup> There seems to be an implicit reluctance at work here to accepting improbable events. It is as if we assume that improbable events are 'actually' probable events, and that we have just 'got it wrong'. But indeterminism implies that some events *are* actually improbable.

isolated event there is no 'often'. There is only one event. An isolated event is consistent with both hypotheses.

Things would be different if we had access to more events.<sup>144</sup> If, during a significant number of rolls, a die landed showing '3' more often than one in six rolls, then we may consider that the 'loaded' hypothesis is better than the 'fair' hypothesis. But this is only because we can compare the hypothetical probability distributions implicit in the two hypotheses with the actual frequency distribution of '3' in the rolls. If the actual frequency of '3' is close to 1/6, then it supports the fair hypothesis, or if the actual frequency of '3' is greater than 1/6, then this supports the loaded hypothesis. But one roll does not do anything to differentiate the hypotheses because it is consistent with both.

If we accept the existence of indeterminism, then confirmation theory cannot establish the most probable hypothesis based solely on the evidence of an isolated indeterministic event. This is because every hypothesis that gives the event a non-zero probability is equally supported by the occurrence of the event. In other words, the hypotheses are empirically indistinguishable. The only hypothesis that the occurrence of the event does not support is the hypothesis that gives the event an epistemic probability of 0.<sup>145</sup>

#### *9.2.4 The implications for self-evidencing explanations*

I began with Lipton's suggestion that the circularity inherent in self-evidencing explanations is benign. But, in the case of isolated events this circularity is not benign. The circularity is vicious. It leads us to accept or reject hypotheses that have no more nor less support than rival hypotheses. The vicious circularity is due to 'double counting'.

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<sup>144</sup> An argument could be made that once I have conceded that an isolated event cannot be used to make a probabilistic inference, then a population of events cannot be used either, simply because a population is no more than a collection of isolated events. If this is the case, confirmation theory fails for all probabilistic inferences based on populations of events. However, I will not pursue this argument here.

<sup>145</sup> Confirmation theory has its own problems with epistemic probabilities of 0. The structure of the calculus dictates that they stay at 0 regardless of conditionalization on new evidence, but we do not need to concern ourselves with this problem here.

Self-evidencing explanations comprise two elements, the hypothesis and the evidence. The evidence confirms the hypothesis because the hypothesis explains the evidence. If there is a real distinction between the evidence and the hypothesis, then there is a potential for benign self-evidencing explanation. However in the case of isolated events, there is no such potential, because the evidence and the hypothesis are indistinguishable. The evidence and the hypothesis are effectively the same information.<sup>146</sup> We accept the most probable evidence/hypothesis pair. But this choice seems to be due to our epistemic preference for our explanations to make things probable. There seems to be the following implicit assumption in our epistemic processes: *events that happen are probable*. But in an indeterministic world we cannot afford this epistemic luxury.

#### 9.2.5 *Solving the problem*

Consider again the die and the probability of rolling a 3. It is *high* on the loaded hypothesis, but *low* on the fair hypothesis. The problem is that we are comparing two probabilities when in reality there is only one. There is only one roll of the die and the only probability we are really dealing with is the ontic probability of the die rolling 3 on that roll. The ontic probability of the die rolling 3 cannot be *both* high and low on the same roll; it is *either* high or low. The die is either loaded or fair; thus the event of rolling 3 was either probable or improbable. It could have been probable and happened, or it could have been improbable and happened. The problem is that the single roll '3' is compatible with both these scenarios. In the case of a single roll there is no way to distinguish the two explanations. They are empirically indistinguishable.

There is no problem if we have access to a large number of rolls. If we have access to the statistical data associated with many rolls, then we can use this data to compare explanations. Consider again the 'loaded' or 'fair' die. If we have statistical data from a large number of rolls, then we can construct an empirical frequency distribution. We can then compare that empirical frequency distribution with the hypothetical probability

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<sup>146</sup> This point relates to the issue of whether a certain hypothesis is testable. If a hypothesis is not testable by independent means, then there is no way to determine its truth.

distribution generated by each explanation. If the empirical data matches one epistemic probability distribution better than it matches the other, then we have reason to say that one explanation is confirmed by the data, more than the other. This is the application of the *conformity maxim*.<sup>147</sup> Confirmation theory cannot be used to distinguish between competing hypotheses with respect to isolated events when both hypotheses give a non-zero probability to the events. But this is also a limitation faced by the conformity maxim; it too cannot be used for isolated events, because it is limited to situations in which we have access to frequency data.

What is the upshot of these considerations? I have highlighted explanatory error. I have warned against using a process that attempts to raise the epistemic probability of events above their ontic probability. I have uncovered the fact that using confirmation theory to decide between hypotheses can lead to error when used in reference to isolated indeterministic events. Does this mean that we cannot explain isolated indeterministic events?<sup>148</sup>

#### 9.2.6 *The problem of confirmation*

The assumption that *events that occur are ontically probable*, explains the central confirming relation between evidence and hypothesis in confirmation theory.<sup>149</sup> If we assume that events that occur are ontically probable events, then it is reasonable that we should confirm hypotheses that make these events epistemically probable. But in an indeterministic world, we cannot infer the probability of an isolated indeterministic event. David Hume argued, “there is nothing in any object, consider’d in itself, which

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<sup>147</sup> It may be possible in this situation to conduct a probabilistic analysis to determine which of the competing epistemic probability distributions best matched the empirical frequency distribution. Such an analysis may be related to Reichenbach’s ‘higher level’ probabilities (Fetzer 1970) 478.

<sup>148</sup> Interestingly this is very close to what Aristotle has to say about scientific explanation. If I am attempting to explain the universe as a whole, then Aristotle will argue that this cannot be based on scientific knowledge, because by definition the universe is not a species, type or sort.

<sup>149</sup> This is an understandable assumption. Given my limited epistemic capacities, I need to order the world in such a way that I can separate probable events from improbable events. Then I can learn to manage the events that are in the probable partition, and leave to fate the events in the improbable partition. An alternate (normative) formulation of this maxim is “Make the events I see epistemically probable”.

can afford us a reason for drawing a conclusion beyond it" (Hume 1984) 189. This statement can be applied to conclusions concerning the probability of isolated indeterministic events. We cannot draw any conclusion about the ontic probability of an isolated indeterministic event based solely on the occurrence of the event *consider'd in itself*. We cannot point to other events of similar type (if such events have occurred) because we are considering the event in isolation.

Let us consider some isolated event, and ask: why is this event ontically probable? We might be tempted to say that it is *probable* that this event is probable. But this response is circular (or would lead to a regress). To claim that an event is probable, because it is probable that it is probable, is to beg the question. In short, there is no way to establish the ontic probability of an event considered in isolation. This neatly parallels Hume's observation that "there is nothing in any object, consider'd in itself, which can afford us a reason for drawing a conclusion beyond it". If we consider the universe as an isolated event, then Hume would counsel that we cannot draw a conclusion beyond it.

## 10 Explanation Indication

### 10.1 The desire for explanation

#### 10.1.1 *Why do we want explanations?*

This question is often overlooked but it is useful to reflect on it briefly. As Adam Morton notes: "Ignorance is the danger that we will not have the beliefs that we need to understand the world and to live our lives" (Morton 2003) 76. We want explanations because we need them to live our lives. We need information to act in the world. Explanation involves how we process the information we use to function in the world. This process can be illustrated by considering the relation between the world and our knowledge and beliefs about the world. We want our knowledge and beliefs about the world to correspond to the world itself. If this were the case and if our beliefs contained 'explanations', then our explanations would be 'true'. We would have genuine understanding of the world. However, our beliefs may not correspond to reality. If so, the content of our beliefs will not furnish any *genuine understanding* of the world. But regardless of whether our beliefs actually correspond to reality, we need beliefs to motivate our actions. Whether our beliefs bear any resemblance to ultimate reality is debatable, but we need beliefs to function and we want explanations to 'understand' those beliefs.

#### 10.1.2 *What do we want explained?*

Perhaps we want to explain everything. Perhaps we want to banish contingency from the world. Perhaps we are looking for necessity. However, it is important to acknowledge that some things may not have explanations. As we have seen, the time-indexed decay of atoms literally may have no explanation. This relates to the distinction drawn between ontic grounds and epistemic reasons. There may be ontic grounds for the time-indexed atomic decay, but literally there may be no reason (or cause) for the decay. By this I

mean that there is no reason (or cause) that is epistemically accessible to us.<sup>150</sup> Now just as there may be no reason for the atomic decay, there may also be no reason for the existence of the universe itself. This is not a new position. It has long been suggested that the universe is not the type of thing that has a reason (or a cause); it just is.<sup>151</sup> So we must acknowledge the possibility that the fine-tuning of the universe and perhaps the existence of the universe itself has no reason (or cause). Of course we should also allow for the possibility that it does. Let us now consider possible explanatory triggers for the fine-tuning of the universe.

## 10.2 Improbability, contingency and significance

### 10.2.1 Improbability versus contingency

It is generally agreed that improbability *per se* is not sufficient to trigger the need for explanation. This is often illustrated by the example of a lottery. In the case of a fair lottery, it is generally assumed that the fact that a specific person won does not need explanation *because someone had to win*. However it should be noted that there is one situation in which a *fair* lottery does require explanation. This is when *contingency* itself (in this case in the form of chance) *is not acceptable* in an explanation.

Generally we want explanations only of events that we think did not *have* to happen, since there seemed to be alternate possibilities. This is why the best explanations are those that eliminate all such alternatives, as when we discover deterministic causes that make it impossible for their effects not to happen.

When the possibility of an event not happening cannot be eliminated in this way, it may still be reduced. That is how indeterministic causes explain events, by reducing the possibility of their not happening by making the events more probable than they would otherwise have been (Mellor 2003) 224.

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<sup>150</sup> It may also be possible that there is no ontic ground for the decay. But in the absence of an epistemic reason, the presence or absence of an ontic ground is literally beyond our comprehension.

<sup>151</sup> Similar positions have been offered by (Russell 1967) 144, and (Scriven 1966) 130.

But here it is important to note that it is not the improbability but the *contingency* that we are trying to avoid. I contend that ontic contingency in the form of ontic indeterminism (or possibly the exercise of God's free will) cannot be avoided.

### *10.2.2 Significance*

Seemingly most people consider life significant. There may be variation in what *exactly* it is about life that people find significant. Some may find all life significant, others may only find intelligent life significant. But most people find significance in some form of life. Perhaps significance motivates the need to 'explain away' the improbability of the fine-tuning. To understand the role of significance in the fine-tuning debate let me distinguish objective significance from subjective significance. The concept of subjective significance seems uncontroversial. It does not seem problematic for me to claim that this or that aspect of life is subjectively significant. This simply means that life is significant *to me*. However objective significance is another matter. The claim that life (or anything else) is objectively significant is controversial and problematic.

The relation between improbability (or more generally contingency) and objective significance is an important one. There are two interesting positions one can take. Either objective significance and improbability (contingency) are *incompatible*, or objective significance and improbability (contingency) are *not only* compatible but objective significance *derives* its status from improbability (contingency). Obviously these are very different positions.

First consider the possibility that improbability (contingency) is incompatible with objective significance. The probabilistic position is this: *objectively significant events cannot be improbable*. And the modal position is this: *objectively significant events are not contingent (they are necessary)*. If this is true and someone considers that life is objectively significant, then this explains why such a person will seek to 'explain away'

the improbability of the fine-tuning.<sup>152</sup> The implication for subjective significance and improbability is this: *subjectively significant events can be improbable*. And the modal implication is this: *subjectively significant events can be contingent*.

Now consider the opposing position that the objective significance of life *derives* its significance from the fact that it is improbable or contingent. This possibility is motivated by the observation that subjectively significant events are often contingent and improbable. Indeed it seems that it is the contingency of the event, *the fact that it might not have been*, that *makes* it significant. Consider the situation in which some event is necessary. It could be argued that this event *could not be* significant.

These two possibilities strike at the heart of the very meaning of significance. I hold that significance is fundamentally non-objective. (I will not offer an extended defence of this position here.) But, I contend that significance motivates much of the fine-tuning debate. The urge to remove the improbability of the fine-tuning may be motivated by the assumption that life is objectively significant.

### 10.3 Surprise

Several authors note that some improbable events require explanation and some do not (Bostrom 2002; Gould 1987; Horwich 1982). Unfortunately, it is not clear what distinguishes improbable events that require explanation from those that do not. Some argue that it is *surprise* that prompts the need for explanation (Manson and Thrush 2003; White 2000; Horwich 1982; Ramsey 1990). Paul Horwich, Neil Manson, and Roger White all characterise surprising events as events that “challenge our assumptions about the circumstances in which they occurred” (White 2000) 270. This seems essentially sound. These authors proceed to use this to support the basic principles of ‘self evidencing explanations’. They argue that surprising events are made unsurprising by providing explanations that make the events probable. I contend that this use of

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<sup>152</sup> Note that if the position that *objectively significant events are not contingent* is accepted, then the following argument can be offered. If life is objectively significant, then it is necessary. Life is contingent. Therefore (by *modus tollens*) life is not objectively significant.

surprising events as support for 'self evidencing explanations' is a mistake. To examine this, I want to focus on the notion that surprising events "challenge our assumptions" about the circumstances of those events. This notion is essentially sound, but is problematic in cases of isolated ontically probabilistic events.

### *10.3.1 Horwich on surprise*

To my knowledge, Horwich presents the most developed analysis of surprise (Horwich 1982). Consider his position on surprise, based on the relevance criterion.

Unlikely events are happening constantly, which don't surprise us – things which have as minute a probability as those which do. Suppose I fish a coin from my pocket and begin tossing it. I would be astonished if it landed heads 100 times in a row, but that outcome is no less probable than any other particular sequence of heads and tails; yet certainly not every outcome would surprise me, for example an irregular sequence of about 50 heads and 50 tails. Thus, the improbability of an event is not sufficient – but it does seem necessary. So the problem is to specify what further conditions distinguish improbable events, which are, from those which are not, surprising.

To resolve this we should first recognise that our assessment of the subjective improbability of a surprising event derives from our opinions about the circumstances of its occurrence. It is, for example, partly by virtue of the belief that my coin is fair, that I assign such a low probability to 100 consecutive heads. Let  $C$  represent these beliefs about the circumstances and  $E$  be the statement whose truth may or may not be surprising. Then our necessary condition is that our beliefs  $C$  are such as to give rise to  $P(E) \approx 0$ . And the further condition, which I would like to propose, is that  $P(C/E) \ll P(C)$ . In other words, the truth of  $E$  is surprising only if the supposed circumstances  $C$ , which made  $E$  seem improbable, are themselves substantially diminished in probability by the truth of  $E$  (Horwich 1982) 101.

Now consider Horwich's position in the light of my criticism of confirmation theory with respect to the explanation of isolated indeterministic events. The following discussion relates to the limitations of confirmation theory for isolated events. Horwich's analysis of surprising events also relates to repeatable events. So the following discussion should not be taken as a criticism of the application of confirmation theory to repeatable events.

Notice that Horwich believes that "E is surprising only if the supposed circumstances  $C$ , which made  $E$  seem improbable, are themselves substantially diminished in

probability by the truth of E." This relation is derived from the relevance criterion within confirmation theory, but in this case, rather than confirmation, we have *disconfirmation*.

However, in the case of isolated ontically probabilistic events this relation is not justified. The fact that an isolated improbable event occurs in an indeterministic system implies nothing about the probability of the reality of the system. Recall the example of a block of ice that increases in size after being placed in warm water. This event is completely consistent with our current understanding of fundamental dynamical laws (Loewer 2001). However, Horwich using the relevance criterion argues that this event is surprising, because the event reduces the probability of the hypothesis. But it is not reasonable to say that the occurrence of an event that is completely consistent with a theory disconfirms that theory. Indeterminism forces us to reject the confirmation relation that is thought to exist between the probability of isolated events and the probability of hypotheses relating to those events. So in the case of isolated events in indeterministic systems, I reject Horwich's condition that "the truth of E is surprising only if the supposed circumstances C, which made E seem improbable, are themselves substantially diminished in probability by the truth of E" (Horwich 1982) 101. I reject it because in the case of indeterminism the circumstances C (i.e. the indeterministic system itself) do not 'make E *seem* improbable', they *make* E improbable, in that they give E its probability (which is small).

If the fine-tuning is the result of an indeterministic system, then it is not surprising because the improbability of the fine-tuning does not diminish the 'probability' of the indeterministic system that produced it. The indeterministic system simply gives the fine-tuning its probability, which perhaps is small.

### *10.3.2 The conformity maxim and surprise*

Contrast the notion of surprising events "challenging our assumptions" with the idea that good explanations generate epistemic probability distributions that match the ontic probability distributions. I contend that *surprising* events can be understood as events that are *not* conforming to the epistemic probability distributions generated by our explanations. This is similar to the "assumption challenging" that is explored by the

authors above, but there are important differences. The most important difference is that *surprise* is not just related to *improbable* events. If surprise is understood generally as relating to an event not conforming to the epistemic probability distribution generated by the explanation, then probable events can also be surprising by *not* occurring. If we expect an event to occur (because we believe it to be probable) and it does not occur, then this is equally as surprising as the occurrence of an event that we did not expect. So surprising events (probable or improbable) can be generally understood as events that do not conform to our expectations.

*Surprising events do not conform to the hypothetical frequency distribution of events generated by the explanation of the system in which they occur.*

Previously we considered expectation. We expect events to conform to the probability distribution associated with the circumstances of those events. Surprise is closely related to expectation. When an event does not conform to its probability distribution it is *unexpected* and thus *surprising*.

#### *10.3.3 Expectation, surprise and isolated ontically probabilistic events*

Unexpected or surprising events “challenge our assumptions”. Obviously, we need assumptions in order for them to be challenged. What assumptions or expectations can we have about isolated ontically probabilistic events? All that we can assume about an isolated ontically probabilistic event that has occurred is that it is not impossible. *But we can assume nothing more.* We cannot assume that an isolated ontically probabilistic event is either probable or improbable, because we have nothing with which to compare it. Of course, if we had something to compare it with, we could make assumptions that could then be challenged. But in the case of isolated ontically probabilistic events there is nothing to compare it with, so we can form no expectations, and thus we cannot be surprised by such events.

#### *10.3.4 Is the fine-tuning surprising?*

When we take ‘surprising events’ to be those that do not conform to their probability distributions, it is clear that the fine-tuning is not surprising. The fine-tuning is (as far as

we know) an isolated event. Isolated events conform to every probability distribution other than those that indicate such events are impossible. If our understanding of the universe were such as to indicate that the fine-tuning was impossible, then we *would* have cause for surprise! But there is no serious assertion that the fine-tuning is impossible.<sup>153</sup> So we have no reason to be surprised, and thus no *motivation* to explain the fine-tuning because of our surprise. I accept that many people find the fine-tuning surprising, but I contend that they should not. Scriven makes a similar point with respect to the design hypothesis.

The request for an explanation in terms of planning in such cases is appropriate only when what occurs is *contrary* to the laws of chance. It is not contrary to the laws of chance that there should be intelligence in the Universe any more than it is puzzling that an unbiased die should throw the series 1, 2, 3, 4, 5, 6, 1, 2, 3, 4. It would be very puzzling if this happened many times in a row, but there are not several universes in a row: there is only one. That one happens to have some order as well as some disorder. Why does it have some order? Because it has to have some properties to exist, and it happens to have these (Scriven 1966) 129.

#### 10.4 Specification

To understand specification, consider Leslie's *neatness principle*: "A chief reason for thinking that something stands in special need of explanation is that we actually glimpse some tidy way in which it might be explained" (Leslie 1989) 121. This principle is endorsed by van Inwagen.

Suppose that there is a certain fact that has no known explanation; suppose that one can think of a possible explanation of that fact, an explanation that (if only it were true) would be a very good explanation; then it is wrong to say that that event stands in no more need of explanation than an otherwise similar event for which no such explanation is available (van Inwagen 2002) 135.

Central to Leslie's and van Inwagen's approach is our epistemic capacity to think of an explanation. There are two features of this process that must be distinguished. The first is the fact that we can think of the explanation. The second is the fact that the

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<sup>153</sup> I am setting aside the technical impossibility related to the measure zero problem here.

explanation is considered good. There are several ways that an explanation may be considered good. We have considered how explanations are deemed good *because they make the event more probable*. This feature of the principle is problematic with reference to ontic probability but we need not return to that discussion.

Consider the other feature of the principle. The claim is that an explanation is required *because we can think of one*.<sup>154</sup> There are obvious anthropocentric worries here. There is no reason why our ability to conceive of an explanation is a good indication of when an explanation is required. Just because we think an explanation exists does not mean that one actually does exist.

Leslie's 'neatness principle' can be considered as one example of what might be called *explanation construction*. To help understand explanation construction I propose to examine the work of Dembski. Dembski is not closely associated with the fine-tuning debate, but he claims that the fine-tuning is due to God. "The fine-tuning of the universe [is an instance] of specified complexity and signal[s] information inputted into the universe by God at its creation" (Dembski 1999) 233. He made this *design inference* based on the application of his *explanatory filter* (Dembski 1998) 37.<sup>155</sup> He claims the filter can detect design in and of the natural world. Central to Dembski's project is the distinction between *specification* and *fabrication*. This distinction proves very useful in understanding the process of explanation construction in the fine-tuning debate. But before I consider this distinction I will review the basics of Dembski's *design inference*.

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<sup>154</sup> Regarding our epistemic accuracy, it should be noted that Leslie is cautious. Taken strictly, his principle is that if we can think of an explanation, then *some* explanation is required, but not necessarily the one that we thought of (Leslie 1989) 122.

<sup>155</sup> Elsewhere I have argued that this claim is not supported by the application of Dembski's own method (Wood 2003). See also (Fitelson, Stephens, and Sober 1999).

## 10.4.1 The explanatory filter and the design inference

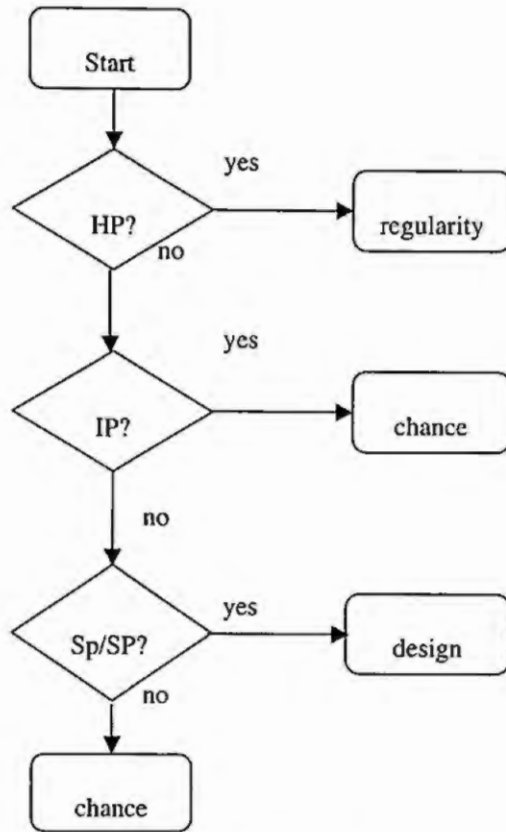


Figure 10:1 Dembski's Explanatory Filter

Dembski's explanatory filter determines the type of explanation of events. The filter indicates whether an event is due to regularity (i.e. a law of nature), chance or design. The filter functions as follows (see Figure 10:1). The probability of an event is determined and then the *description* of that event is considered. Descriptions of events are either *specifications* or *fabrications*. (These terms are explained below.) If the event has a high probability (HP), it is due to regularity; if the event has an intermediate probability (IP), it is due to chance; if the event has a small probability (SP), it is either due to chance or design. If the description of the event is a specification (Sp) it is inferred that the event is due to design. This is the *design inference*. (More precisely,

chance is eliminated.) If the description of the event is a fabrication as opposed to a specification, then design is not inferred. (Again, more precisely, chance is not eliminated.) In the absence of the design inference, the event may be due to chance. The distinction between specification and fabrication is crucial, and relates to the law of small probability.

#### *10.4.2 The law of small probability*

The foundation of the design inference is the elimination of chance in relation to events of small probability. This is based on what Dembski calls *the law of small probability* which states that 'specified events of small probability do not occur by chance' (Dembski 1998) 5. Dembski does not present his own argument to support this law, but refers to historical presentations of it. He quotes Laplace:

On the table we see letters arranged in this order, *Constantinople*, and we judge that this arrangement is not the result of chance, not because it is less possible than the others, for if this word were not employed in any language we should not suspect that it came from any particular cause, but this word being in use among us, it is incomparably more probable that some person has thus arranged the aforesaid letters than that this arrangement is due to chance (Dembski 1998) 1.

Let us grant here that 'specified events of small probability do not occur by chance'.<sup>156</sup>

#### *10.4.3 The event, its description and explanation*

Consider the relation between an event and its description. If we generate the description of an event using the event itself, then this does not justify the elimination of chance. However, if the description of an event is generated independently of the event, then Dembski argues that the elimination of chance is justified. There is an important relation here between the *independent* description of the event and the *explanation* of the event. The generation of the description of the event independently of the event itself is *based on* the possible explanation of the event. The explanation, in effect, *produces* the

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<sup>156</sup> Notice here the similarity with the intuition that objectively significant events are not contingent.

description of the event independently of the actual occurrence of the event. This relation is most obvious in the case of prediction. Before an event occurs, a prediction is made based on an independent hypothesis (explanation). Clearly the description is independent of the event.<sup>157</sup> If the predicted event occurs, then there is a match between the independent description (prediction) and the event. Here the independent description of the event based on the possible explanation of the event underlies the notion of *specification*.

#### 10.4.4 Specification versus fabrication

Because the letters *Constantinople* make a 'word being in use among us' the event of the letters arranged in this order is 'specified', and Dembski claims that it cannot be due to chance. Given that chance has been eliminated, we then seek another explanation, namely design. Contrast this with letters arranged in the following order, *Taorghawin*. Because this word is not 'in use among us' it does not qualify as a specification. The arrangement of letters in this order does not preclude chance, and thus does not prompt us to seek further explanation in the form of design.

Consider a coin example. We take a coin, and before tossing the coin, we record a string of 100 heads and tails. Then we toss the coin 100 times. If the actual series of tosses matches the string recorded, then the event was specified and Dembski's filter would eliminate chance. Now consider the situation in which we toss a coin 100 times and *then* record the string of 100 heads and tails, based on the actual tosses. This would not be a *specification*; this would be a *fabrication*. Fabrications do not eliminate chance. This distinction between specification and fabrication seems intuitively sound.

Dembski allows that events can be specified *after* they have occurred. He argues that if the description of the event is *independent* of the occurrence of the event, then the description can be considered a specification. Dembski asks us to consider a coin toss. He presents an apparently random string of 100 tosses of a coin, Figure 10:2, and

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<sup>157</sup> I am ignoring a common cause or the possibility of backwards causation here.

considers whether they are due to chance (the outcome of a real series of coin tosses) or the result of design (a series, structured merely to look like a chance process) (Dembski 1999) 138-142.

THTTTTHHTHHTTTTTHTHTTHHHTT

HTHHHTHHHTTTTTTHTTTHTTTHH

THTTTHTHTHHTTHHHHTTTHTTTHH

THHTTHHHHTTHHTHHHHHTHHHHTT

*Figure 10:2 One hundred tosses of a coin*

In considering the string of heads and tails he converts the tails to zeros and heads to ones. He now has a string of 100 zeros and ones, Figure 10:3.

0100011011000001010011100

1011101110000000100100011

0100010101100111100010011

0101011110011011110111100

*Figure 10:3 Heads and tails converted to zeros and ones*

On closer inspection this string is recognised as the binary numbers [words], written “in ascending order, starting with the one-digit binary numbers (i.e., 0 and 1), proceeding to the two-digit binary numbers (i.e., 00, 01, 10, and 11), and continuing on up until 100 digits were recorded” (Dembski 1999) 142. Figure 10:4.

0	1	00	01	10	11	000	001	010	011	100
101	110	111	0000	0001	0010	0011	0100	0101	0110	0111
1000	1001	1010	1011	1100	1101	1110	1111	00		

*Figure 10:4 Ascending binary numbers [words]*

So it is possible to specify an event after it has occurred, if the event conforms to some independent pattern. The crucial feature of specification is the independence of the specification. Independence is assumed if the description of the event occurs before the event. However, Dembski claims that descriptions *identified* after the event can also be independent. Although the description is *identified* after the event the description still exists *before* the event. (In the example above, as the *pre-existing* form of the binary word ordering.) If the coin-toss matches a pre-existing pattern, then chance is eliminated. If the coin toss does not match a pre-existing pattern, then chance is not eliminated. The important point is that it is not appropriate to construct a pattern using the event and then argue that the pattern is 'independent' of the event.

#### *10.4.5 Specification and explanation*

Following Dembski, events that are specified need explanation, while events that are not specified (events whose descriptions are fabrications) do not need explanation. If we specify a string of 100 heads and tails before the event and this exact series is tossed, then we would suspect that something is going on. We may not *know* what is going on, but we would be quite uncomfortable attributing this to chance. Similarly if we do not record the 100 tosses beforehand and yet we can recognise in the series of coin toss an independent pattern, then we would also be reluctant to attribute this to chance. However if we do not record the event before hand and there is no independent pattern discernible in the event, then there is no motivation to reject chance as an explanation. For example, if we construct a pattern based on the event itself, and then claim that this is the pattern that the event is conforming to, this is a case of fabrication.

#### *10.4.6 Prior and posterior specification and fabrication*

Let me distinguish two types of specification, *prior* and *posterior*. Prior specification occurs before the event in question. Imagine recording a string of heads and tails before a series of coin tosses, and then the coin landed in the order recorded. This would be odd. Intuitively this implies that the coin was not landing due to chance. This situation

suggests that an explanation other than chance is involved.<sup>158</sup> Given that there is no possibility of humans specifying the fine-tuning before its occurrence, prior specification can be discounted. It could be suggested that God specified the fine-tuning before the event, but this would presuppose God's existence and thus would beg the question. Dembski claims his process can be used to *infer* design. Clearly it would be a flawed inference if it *presupposed* it.<sup>159</sup>

#### *10.4.7 Posterior specification, fabrication and explanation construction*

How we specify an event after it has occurred is intimately related to the explanation of the event. We use the explanation of the event to *construct* the specification. Notice how the knowledge of binary ordering was used to construct the string of 100 zeros and ones. The ordering dictated the order of zeros and ones in the string. Contrast this with fabrication. If the binary ordering example were a case of fabrication, then the direction of the process of construction would be reversed. The *structure* of the binary ordering would be *constructed* using the string of zeros and ones. We would construct a binary word order such that it produced the order of zeros and ones in the string. Imagine that no binary word order existed and then a coin was tossed. Then a 'binary' word order would be constructed using the string of zeros and ones as the template for the first one hundred digits of the order. The distinction between posterior specification and fabrication is related to the *direction* of the process of construction. Posterior specification uses the explanation to construct the description of the event, while fabrication uses the event itself to construct the description of the event. So specification *leads to* the event, while fabrication *comes from* the event.

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<sup>158</sup> There is the possibility of a common cause explaining the prior specification and the matching event. But I need not consider that possibility.

<sup>159</sup> One other possibility is that the fine-tuning is somehow independently defined 'necessarily' in the realm of mathematics. But if this were the case, the explanatory filter would indicate regularity not design.

10.4.8 *Is the fine-tuning a case of posterior specification or fabrication?*

Applying the explanatory filter, the fine-tuning, as an improbable event, is either due to chance or design. To determine the appropriate explanation we need to determine whether the description of the fine-tuning is a fabrication or a specification. Bracketing prior specification, we need to determine whether the description of the fine-tuning is a case of posterior specification or fabrication. If the description of the fine-tuning is a posterior specification, then using Dembski's filter, we infer design. If the description is a fabrication, then we do not infer design. So is the description of the fine-tuning specification or fabrication? Is the description of the fine-tuning constructed independently of the event or based on the event?

Understood in the terms of specification and fabrication as defined by Dembski, I contend that any description of the fine-tuning can only be a fabrication.<sup>160</sup> In the process of description construction, Dembski allows for multiple descriptions (Dembski 1998) 150. As long as one description matches the event, then Dembski's requirements have been met. For the fine-tuning to be a posterior specification, we would need to *accurately and independently* describe the universe, *without reference to this universe*. But to ensure the accurate description of the fine-tuning we would need to describe every logically possible universe. This is beyond our capacities. (Here I discount the possibility that a finite set of descriptions 'just happened by chance' to match the actual fine-tuning.)

To infer that the universe is designed we need to identify a *specification* of this universe based on some independent possible explanation. One such explanation could be that God wanted a universe with intelligent beings, and so fine-tuned the universe to allow for their existence. But we must be careful here. Is this explanation generated independently of the existence of this universe? Beings with desires exist in this universe. Clearly these beings are not *independent* from this universe. So the actual

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<sup>160</sup> Further, if we use the explanatory filter strictly as Dembski stipulates, there are technical problems that I have explored elsewhere (Wood 2003).

existence of beings with desires cannot be used to construct the explanation. The crucial question is whether the *concept* of a being with desire is independent of the actual existence of beings with desire in this universe. The *concept* of God having a desire to create a universe may not be independent of the existence of beings with desires in this universe. The idea of a God with desires may be a *fabricated* explanation based on the actual existence of intelligent beings with desires in this universe. We do not know if such a concept is independent of this universe. Here I hold that the burden of proof lies with the advocates of design. The independence of the concept of a God with desires needs to be demonstrated. If this concept is independent of the existence of similar beings in this universe, then this could be a case of posterior specification and thus chance is eliminated. But if this concept is in fact a fabrication, based on the actual existence of intelligent beings with desires in this universe, then chance is not eliminated. Fabrication is simply a modern version of the traditional anthropomorphic criticism of the design argument (Hume 1969).

This analysis prompts the question: what description could possibly be independent of the existence of this universe? If every description based on anything that exists in this universe is not independent, then it seems that there can be no independent descriptions. However there is an intriguing possibility related to mathematics. Possibly mathematics is independent of the existence of this universe. If it is, and if we can construct an independent description of this universe based on mathematics, then we might have a specification. Interestingly Dembski chooses a mathematical example to illustrate the concept of posterior specification. Mathematics and perhaps logic may be the only truly independent methods of specification. It is possible that mathematics has the necessary independence from the actual existence of this universe. But a specification of the fine-tuning based on mathematics would not necessarily imply design. We could not use the existence of this universe to help in the construction of the description, and the description would carry no weight if it corresponded to the universe just 'by chance'. So it seems that if we were to succeed in constructing a description of the universe based on mathematics, then we could only succeed if the description somehow arose necessarily out of the structure of mathematics. However, if this were the case, then the *improbability* (that is required to infer design in the structure of the filter) is replaced

with *necessity*, so the inference to design would again not be warranted. (The filter would yield regularity.) If an inference to design is warranted here at all, then it is the mathematics not the fine-tuning that is the candidate for being designed.<sup>161</sup>

#### *10.4.9 Self-evidencing explanations called into question*

It is illuminating to consider Dembski's work in relation to my criticisms of self-evidencing explanations (such as Leslie's *neatness principle*) and confirmation theory, with reference to isolated events. Dembski shows us that we must beware of fabricated explanations based only on the occurrence of an event, rather than on independent grounds. If we consider this fine-tuned universe as all there is, then it can be considered as an isolated event. So when attempting to explain the universe, it will be difficult to avoid the charge of fabrication, simply because there is nothing that is independent from it. Now with reference to Leslie's neatness principle, we can see that the only reason we can think of an explanation is because we have experience of this universe. We have experience of beings with desires, and this is the basis of the God explanation. But we have no reasons for believing that beings with desires have any existence independent of this universe. We have no way of knowing that we have not fabricated this explanation.

### **10.5 Analogies**

Analogies are used extensively in the fine-tuning debate (Leslie 1989; van Inwagen 2002; Swinburne 1991). Situations are presented that require explanation, and these situations are presented as analogous to the fine-tuning. Thus by analogy, the fine-tuning is taken to require explanation. I now consider the structure of these analogies in the light of my discussion of specification and fabrication. I contend that the analogies are not genuinely analogous to the fine-tuning and so they do not give us reason to seek an explanation for it. To begin we need to distinguish two distinct uses of analogy in the fine-tuning debate. The first is intended to indicate that the fine-tuning requires explanation. The second is specifically employed to illustrate features of the

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<sup>161</sup> This relates to the question of whether God is responsible for mathematical and logical necessities.

*observational selection effect (anthropic principle)*. As mentioned previously, the observational selection effect debate is not central to this analysis.<sup>162</sup> I will focus on the use of analogy to argue that the fine-tuning requires explanation.

#### *10.5.1 Analogies to prompt explanation*

The following analogies are presented as requiring explanation.

You seem to see mere rubbish in your opponent's poker hand of an eight, six, five, four, and three. It is natural to assume that Chance gave it to him. But you then recall that poker has many versions; that you had agreed on one in which his Little Tiger ('eight high, three low, no pair') defeats your seemingly much stronger hand; that a million dollars are at stake; and that card players occasionally cheat. At once your suspicions are aroused (Leslie 1989) 9-10.

In this analogy the 'chance' event is the deal that gave your opponent his hand of cards. The independent definition (specification) is the choice of the version of poker involving the 'Little Tiger'. It is important to note that if you had not agreed beforehand on this version of poker, then this deal would not be a specification and not require explanation.

Any hand of thirteen cards is in an important sense exactly as unlikely as any other, but our suspicions are aroused when we watch Smith winning a million dollars with a hand of thirteen spades that Smith has dealt to Smith. We do not just say 'Lucky Smith!', disregarding the explanation that stares at us (Leslie 1989) 121.

Again the deal of cards is the 'chance' event. The independent definition (specification) is the agreement that the hand of 13 spades will win a million dollars. Again, without that independent agreement defining 13 spades as the winning hand, then 13 spades would not be a specification.

Any car number plate will be in some sense 'improbable'. There are millions of number plates and only one CHT 4271, for instance; it was therefore unlikely that you would get that number plate on your birthday car; yet your getting it has no special interest. But what if Bob, born on the 8th day of

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<sup>162</sup> For an analysis of the observation selection effect see (Bostrom 2002), and for an analysis of the use of analogies in the fine-tuning debate with specific reference to the OSE see (Carlson and Olsson 1998).

August (the eighth month), finds BOB 8893 on his birthday car in 1993? He would be obtuse if he commented, 'Nothing remarkable in that!' (Leslie 1989) 121.

In this analogy the number on the number plate is the 'chance' event. The independent definition is the fact that Bob was born when he was. The specification is the fact that the sequence of letters and numbers on the number plate match Bob's birthday. If BOB 8893 did not match Bob's birthday in 1993, then there would be no specification.

You know that a lake's impenetrably cloudy waters contained a fish 23.2576 inches long, for you have just caught the fish in question. Does this fact about the lake stand in specially strong need of explanation? Of course not you tend to think. Every fish must have some length! Yet you next discover that your fishing apparatus could accept fish of this length, plus or minus one part in a million. Competing theories spring to mind; the first that there are millions of differently lengthed fish in the lake, your apparatus having in the end found one fitting its requirements; and the second, that there is just one fish, created by someone wishing to give you a fish supper. Either explanation will serve; and so for that matter will the explanation that the well wisher created so many fish of different lengths that there would be sure to be one which you could catch. ... In contrast, *that the one and only fish in the lake just happened to be of exactly the right length* is a suggestion to be rejected at once (Leslie 1989) 9.

The 'chance' event in this situation is the catching of the fish 23.2576 inches long. The independent definition of this event is the existence of the fishing apparatus before the fish is caught. If a fish is caught using this pre-existing apparatus, then this is a case of specification.

Suppose that you are in a situation in which you must draw a straw from a bundle of 1,048,576 straws of different length and in which it has been decreed that if you don't draw the shortest straw in the bundle you will be instantly and painlessly killed: you will be killed so fast that you won't have time to realize that you didn't draw the shortest straw. Reluctantly – but you have no choice – you draw a straw and are astonished to find yourself alive and holding the shortest straw. What should you conclude?

In the absence of further information, only one conclusion is reasonable. Contrary to appearances, you did *not* draw the straw at random; the whole situation that you find yourself in is some kind of "set-up"; the bundle was somehow rigged to ensure that the straw that you drew was the shortest one (van Inwagen 2002) 152.

The 'chance' event in this situation is the drawing of a straw. The independent definition is the relation between the shortest straw and your life, namely that if you draw the shortest straw you will not be killed. If the independent definition of 'drawing the shortest straw will save your life' is not designated beforehand, then the fact that you drew the shortest straw cannot be a specification.

Suppose that a madman kidnaps a victim and shuts him in a room with a card shuffling machine. The machine shuffles ten packs of cards simultaneously and then draws a card from each pack and exhibits simultaneously the ten cards. The kidnapper tells the victim that he will shortly set the machine to work and it will exhibit its first draw, but that unless the draw consists of an ace of hearts from each pack, the machine will simultaneously set off an explosion which will kill the victim, in consequence of which he will not see which cards the machine drew. The machine is set to work, and to the amazement and relief of the victim the machine exhibits an ace of hearts drawn from each pack. The victim thinks that this extraordinary fact needs an explanation in terms of the machine having been rigged in some way (Swinburne 1991) 138.

The 'chance' event is again the drawing of cards and the independent definition is the relation between the *ace of hearts* cards and your life. If this pre-existing designation of cards is not made, then there is no possibility of specification.<sup>163</sup>

All these analogies have the same structure.

*Independent Definition (Specification) → Occurrence of 'Chance' Event.*

I grant that these situations do require explanation. This is because the 'chance' event matches the independent definition, or specification.

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<sup>163</sup> Notice in the last two analogies, the unfortunate person in question is alive both before and after the 'chance' process. Both these analogies have been used to criticise the following formulation of the observer selection effect argument: I should not be surprised about being alive, because the only way I can witness the 'surprising' event is if I am alive. This formulation of the OSE argument is erroneous, as is correctly pointed out by the two authors using the analogies. However, neither of these situations is analogous to the fine-tuning, because we (mortals) did not exist before the fine-tuning. Dowe has noted that observer selection reasoning may depend upon the notion that we are 'disembodied souls floating over universes waiting for a fine-tuned one to appear so that we can find a home' (Dowe 1999) 68.

10.5.2 *Is the fine-tuning analogous to the 'analogies'?*

I contend that the fine-tuning of the universe is not analogous to these situations.<sup>164</sup> So the fact that these situations need explanation does not imply that the fine-tuning needs explanation. To examine this, consider the form of the analogies.

*Independent Definition (Specification) → Occurrence of 'Chance' Event.*

The fine-tuning of the universe is the *occurrence of the 'chance' event*. For it to be analogous, there needs to be an *independent definition*. If there is, then it is analogous and thus requires explanation. If there is not, then it is not analogous and thus does not require explanation. So, does the fine-tuning have an independent definition?

In all the above 'analogies' there is some aspect of the situation that independently defines the 'chance' event in some way. In the poker example, it was the fact that the 'Little Tiger' was independently defined in the version of poker chosen *independently of the deal of the cards*. In the fishing example, it was the fact that you had a certain fishing apparatus that could only catch fish 23.2576 inches long *independently of the catching of the fish*. For the analogies to be genuinely analogous, the fine-tuning needs to be independently defined. But there is no such definition. The only way to make the fine-tuning match the analogies is to *assume* that it is defined independently of the universe. But how can the fine-tuning be defined independently of the universe?

One way that the fine-tuning can be independently defined is in the mind of God. But this begs the question. Another way that the fine-tuning could be independently defined is if it is implied by mathematics (or logic) in some way. There are two ways that mathematics could imply the fine-tuning. Firstly, the fine-tuning could be a necessary implication of mathematics. If this is the case, then it is not the fine-tuning that needs explanation but the underlying mathematics. And such mathematical necessity is not the sort of independent definition that is normally associated with design. Secondly, the

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<sup>164</sup> A similar position regarding the analogies in this debate is presented by (Carlson and Olsson 1998).

fine-tuning could be implied by the mathematics in some probabilistic sense. I take probabilistic specification to be the notion that an event has some positive probability of occurring. The mathematics involved with quantum mechanics may be a possible source of probabilistic specification. But this is not the type of specification that justifies the inference to design. Without an independent definition, the description of the fine-tuning can only be a case of fabrication.

### 10.5.3 Making the 'analogies' analogous

Consider how the analogies would look if they were genuinely analogous to the fine-tuning. Begin with the 'Little Tiger' scenario. Deal a hand of 5 cards. The hand of cards is: eight, six, five, four, and three. But this time no arrangement is made beforehand regarding what cards will be significant or even what game is being played. If any such assumptions are made, then we fall back into begging the question. Nothing can be significant unless it is defined as such in some system of meaning. Given this scenario there is simply no reason to prompt explanation. To bring the point home, imagine that you are playing poker and you have just been dealt the following hand: three, five, six, and nine. Imagine now, *with the cards in your hand*, you suggest to your opponent that you change the rules you are using to give your 'Little Lion' significance. This is equivalent to fabrication, and it is exactly what is attempted in the fine-tuning debate. After the event of the fine-tuning, it is claimed that the fine-tuning has independent significance. Notice the similarity with Scriven's example of throwing a die 10 times.

If we decide to throw a die ten times, then it is guaranteed that a particular one of  $6^{10}$  possible combinations of ten throws is going to occur. Each of them is equally likely; each of them is entirely distinct from each other possibility. And each of them, if we study it closely, has interesting properties. Now it would be pretty silly for the combination that happens to come up, to sit and look at itself and suggest that there had to be a designer who deliberately manipulated the fall of the die in order to bring about the particular combination that did occur (Scriven 1966) 129.

Or consider the fishing analogy. For this analogy to be genuinely analogous the whole story has to be different, but this serves to illustrate the strength of the *dis-analogy*. Imagine that you are in a boat without any fishing equipment. A fish jumps into your boat. You then *build* a fishing apparatus around the fish such that it will only catch a

fish of this size. Or consider a lottery.<sup>165</sup> Someone wins this lottery. Should we be suspicious of this win? Should we believe that the lottery was rigged? That depends on the circumstances. Perhaps the lottery organiser's daughter won. This seems suspicious. But perhaps the person who won is of no relation to the lottery organiser. The requirement to explain the win depends on the pre-existence of the appropriate relation between the winner and the organiser. We can certainly check if the winner is related. But the *idea* that the winner might be related to the organiser does not *make* the winner related. *They either are related or they are not.* If the winner is related to the organiser, then this is a case of specification. But if we merely *construct* some form of relation between the winner and the organiser this is not a case of specification, it is clearly fabrication.

#### 10.5.4 Begging the question

We have been unable to construct an independent description of the fine-tuning. However this does not imply that an independent definition does not exist. Presumably an independent description either exists, or it does not. If it does exist, then we are justified in inferring design; if not, then we are not. But this is no better than saying that if the universe is designed, then it is designed; if not then not!

Another way of approaching the concept of independent description is the attribution of objective significance.<sup>166</sup> If the objective significance of the fine-tuning could be

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<sup>165</sup> Lottery examples can be criticised because they assume the existence of a chance set up, including tickets that did not win. The criticism is that in the case of the fine-tuning there is not necessarily a chance set up, or any other universes that correspond to the tickets that did not win. However, the existence of other tickets is not central to the force of the analogy. A single roll of a die is less confusing, but such a set up still assumes that other numbers could have been rolled. For this analogy to be valid we must assume that the fine-tuning could have been otherwise; i.e., it is contingent. Most people are happy to concede this, but some are not. Mellor believes "that the necessary uniqueness of the world as a whole, deprives the hypothesis, that it is the outcome of a chance process, of any sense" (Mellor 1973) 480. This is a serious criticism. If by this Mellor means that it is meaningless to say that the world as a whole is contingent, then no analogy that incorporates a contingent process can be used to imply anything about the fine-tuning. As we have already seen, while he is comfortable with the notion of a *material* chance set up, like the roll of a die or the decay of an atom, Mellor is uncomfortable with the notion of an *immaterial* 'chance set up' (Mellor 1973) 476.

<sup>166</sup> Objective significance could be related or unrelated to the existence or non-existence of God.

demonstrated, this might go some way towards the generation of an independent description. But critics would argue that *objective* significance was a fabrication based on *subjective* significance. Here, both sides can be accused of begging the question. Advocates of design and/or objective significance can claim that there is an independent description, while critics of design and/or objective significance can claim that there is no independent description: only fabrication based on human desire or subjective significance. We have arrived at an impasse.

In order to require explanation of the fine-tuning (in the form of design) it must have some independent definition. If we consider it to be *objectively* significant (i.e., by conforming to some *independent* pattern), then we will seek a design explanation. But equally, if we do not see it as objectively significant (i.e., in the absence of some independent pattern), then we will not seek a design explanation. Both positions can be accused of begging the question. If the fine-tuning is not significant, then it is analogous to the lottery in which someone unrelated to the organiser wins, and if the fine-tuning is significant, then it is analogous to the lottery in which the organiser's daughter wins. But the fact that we can *think* "the person who won is the daughter of the lottery organiser" does not *make* the winner the daughter of the organiser. The winner either was the daughter of the organiser or she was not. In this situation, to claim that the winner *is* the daughter *because we can think that she is* would be a case of fabrication. To claim that the winner is the daughter of the organiser *because we have her birth certificate* would be a case of specification. In the case of the fine-tuning, it is either independently defined or it is not. *Thinking* that it is independently defined does not *make* it so. Until we find an independent description of the universe, there is no justification to infer design.

## 11 Explaining the Fine-Tuning

### 11.1 Considering the options

We have considered various responses to the improbability of the fine-tuning. Now we need to decide which is the appropriate one. We will focus on the multiple universe, God and ontic field explanations. But first let me review some other options.

The fine-tuning of the universe may be necessary. By this I do not mean that the universe necessarily exists, but rather that if any universe exists, then the fine-tuning of any such universe must be as it is in this universe. There may be underlying ontic grounds that ensure that if any universe exists, then the values of the universal parameters are the values that we find. If this is the case, then this universe could not have been otherwise. We may or may not have epistemic access to the ontic ground of this necessity. If we do, then there will be a 'reason' for this ontic necessity that we will be able to understand (perhaps in the form of scientific theory). But on the other hand we may not have epistemic access to this necessity. The form of the fine-tuning may be ontically necessary, but perhaps we will never be able to comprehend *why*. Another option is that the fine-tuning could be logically necessary. This would imply that this universe could not have been otherwise because it is the only logically consistent one.<sup>167</sup> However, while acknowledging that the fine-tuning of the universe may be ontically or logically necessary, we currently have no good reason to embrace these possibilities, so let us leave them for now.

We also considered the possibility that the fine-tuning was due to chance operating in the logical possibility space. Scriven argues that given that the universe exists, it must have some properties, and it just happens to have these (Scriven 1966) 129. Scriven contends that chance is a suitable explanation for the properties that this universe happens to have. Further he argues that some other explanation for this universe is only

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<sup>167</sup> Davies believes that this is demonstrably wrong (Davies 2003). This option is distinct from a logically necessary universe, because although there may be only one logically consistent universe, this does not imply that such a universe necessarily exists.

required if the existence of this universe is *contrary* to chance.<sup>168</sup> Here we consider chance as operating in the logical possibility space. This universe, as a single universe in the logical possibility space, is not contrary to chance.<sup>169</sup> However explaining the fine-tuning based on the idea that it was determined by chance operating in logical possibility space is unsatisfactory. More effort can be made with respect to the attempted explanation. So let me set aside this explanation. The ontic field explanation that we consider later involves chance operating in *less than* the total logical possibility space.

Next consider explanations based on a chaotic or quantised ontic possibility space. Although the fine-tuning debate is normally considered as a debate about fine-tuning *for life*, the concept of fine-tuning *itself* can be considered independently. Perhaps there is an explanation for fine-tuning *per se*, regardless of *what* the universe is fine-tuned *for*.<sup>170</sup> It may be that the ontic possibility space of universes is chaotic. If the system that produced our universe is chaotic, then universes *adjacent* to ours in the possibility space will have manifestly different structure (for example, different spatial and temporal dimensions, force types and strengths, and particle types and masses). This would go some way toward explaining why universes that are 'slightly different' to ours, as defined by their location in the possibility space, are very different in manifest structure. Now this would not explain why our universe is fine-tuned *for life*, but it is a possible explanation of why the universe is fine-tuned *per se*.

Similarly, if the possibility space of universes is quantised this may also help understand the fine-tuned nature of our universe. In a chaotic system, slightly different universes are

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<sup>168</sup> Scriven's position, that we only require explanation if an event is contrary to chance, has an important implicit assumption that is worth highlighting. Notice that Scriven is using chance as the default explanation. So Scriven starts with chance and is only prompted to seek another explanation if the event is contrary to chance. However, it is also possible to use 'non-chance' as the default explanation. It is possible to assume that every event has an explanation that does not involve chance. Using this approach we would only explain an event as due to chance if we have failed to find a non-chance explanation. This second approach seems to assume that chance is simply a reflection of our ignorance, and that really there are no chance events. Notice that this second approach seems to contradict modern physics.

<sup>169</sup> This is consistent with the application of the conformity maxim. We need only look for another explanation if the event does not conform to the probability distribution generated by the current one.

<sup>170</sup> The language of the debate is misleading here. The universe may not be fine-tuned *for* anything.

possible, *but very different*. However in a quantised system slightly different universes are not ontically possible. If the ontic possibility space of universes is quantised, then all ontically possible universes will be different from other ontically possible universes by a 'quantum' amount. This applies to every ontically possible universe, so no ontically possible universe will exist that is 'slightly different' to any other ontically possible universe. Thus 'slightly different' universes do not allow of life because they are not ontically possible.<sup>171</sup> It is unclear whether current cosmology is consistent with a quantised possibility space of universes, but modern physics does not obviously exclude this idea. Both the chaotic and quantised possibility spaces seem productive lines of enquiry to help understand the reason this universe is fine-tuned. But, while they may explain the fine-tuning *per se*, neither of these explanations necessarily explains the fine-tuning *for life*. Given that these ideas are speculative, I will not pursue them further here.

## **11.2 Multiple universes**

The central notion of multiple universes is that there may be many 'domains' either spatially and/or temporally distinct in the totality of existence that can be considered different universes. The basic idea is that if there are many such universes with different values for the constants of nature, laws and initial conditions, then it is understandable that at least one of those universes allows for life.

There have been several versions of the multiple universe theory. The main distinction to be made relates to whether the model involves *all* possible combinations of initial conditions and fundamental constants or merely a large number of different

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<sup>171</sup> This suggestion is more tenuous than the chaotic version. For this approach to be meaningful it must first be possible to demonstrate that slightly different universes are not ontically possible. Furthermore, we must be clear about what we mean by 'a universe'. For instance, if a 'slightly different universe' only existed for a fraction of a second, and did not get larger than a basketball, would we call it a universe? Even if the 'basketball universe' were ontically possible would we recognise it as a universe? Here we see another version of the selection effect. This is really a 'definitional' selection effect. If by 'universe' we mean something that has the characteristics of our universe, then we have already discounted many possible 'states of affairs' from being considered as universes. Thus the boundary between the concepts of a chaotic possibility space and a quantised possibility space is not necessarily clearly defined.

combinations. There are two modalities available here, logical or ontic.<sup>172</sup> If all logically possible combinations actually exist, then this explains the fine-tuning. This is because the existence of all logically possible combinations implies the existence of this finely-tuned universe. If all ontically possible universes exist, then this explains the fine-tuning to some extent, but it does not explain why this finely-tuned universe is ontically possible. But if all logically or ontically possible combinations do not exist, then the force of these explanations is reduced.

The theoretical motivation for this explanation is due to the generally accepted view that some of the fundamental features of the universe are the result of a ‘symmetry breaking mechanism’ (Davies 2004) 728. The basic idea is that in the early moments of the universe, the symmetry of a more fundamental state of reality ‘broke’ resulting in the fixing of the strengths of the four fundamental forces and the masses of the particles. Additionally, it is claimed that the symmetry breaking could have resulted in different forces and masses, and that the process could have been different in different domains.

#### *11.2.1 Versions of the ‘multiverse’ theory*

There are various version of the ‘multiverse’ theory.<sup>173</sup> Carter proposed that all logically possible universes consistent with classical big-bang cosmology actually exist (Carter 1974). John Wheeler proposed that our universe was just one of many universes in a temporal series, each one related to the next through a process of expansion and contraction (Wheeler 1990). Hugh Everett proposed a theory based on the ‘many worlds’ interpretation of quantum mechanics (Everett 1973). Everett’s interpretation shares with the Copenhagen interpretation the concept of a wave function  $\psi$  that represents the superposition of all possible outcomes of a measurement interaction. But while on the Copenhagen interpretation only one possible outcome is instantiated, on Everett’s interpretation all possible outcomes are instantiated. So each time there is a ‘measurement interaction’ the universe branches into distinct, *equally real* universes.

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<sup>172</sup> I am assuming that the logical and ontic possibility spaces are not co-extensive.

<sup>173</sup> This discussion of multiverse theories draws from (Davies 2004) (Smith 1986) and (Leslie 1990).

Another version developed by Alex Vilenkin and Andrei Linde considers our universe as one bubble in a vast (possibility infinite) foam of other universes (Vilenkin 1983) (Linde 1983). Recently Lee Smolin suggested that 'baby universes' may be produced via a process of gravitational collapse in a black hole (Smolin 1997). And Max Tegmark suggested that all logically possible universes actually exist (Tegmark 2003).<sup>174</sup>

Of particular relevance here is the quantum vacuum fluctuation theory suggested by Tryon (Tryon 1990). This explanation suggests that our universe is a fluctuation of the quantum vacuum. Most cosmological models assume quantum theory. Quantum theory includes the notion of the quantum field and the fluctuation of the quantum vacuum. The quantum field exists independently of this material universe. The quantum vacuum is the lowest energy state of the quantum field and a vacuum fluctuation is a modification of the quantum field (van Inwagen 2002) 131. A vacuum fluctuation is an event in which matter spontaneously emerges from the vacuum, exists for a finite time, and is then annihilated. Given certain constraints, this universe may be the product of such a vacuum fluctuation. This explanation is usually classed as a multiple universe explanation, but later I will consider this idea as an explanation that does not involve 'other universes'.

### *11.2.2 The general form of multiverse explanations*

Now consider the general form of multiverse explanations. The explanation has three general features. (1) The assumption that there are many universes. The strength of this form of explanation is considered to rest on the number of universes. If there are few universes, then this explanation is considered weak. The more universes there are (up to all logically possible universes) the stronger the explanation. (2) The assumption that these universes have different values for the so-called 'finely-tuned' constants and initial conditions. If all the universes have the same values for the so-called 'finely-tuned' features, then the fact that there are many universes is irrelevant. (3) The

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<sup>174</sup> Tegmark mentions the idea of universes based on the mathematics of fractals. This may support my suggestion that the ontic ground of this universe is chaotic.

acknowledgement of the 'observational selection effect'. We as observers must be in a universe that allows for our existence as observers.

So with these three features in mind, the general form of the explanation is as follows.

*If there are very many universes with different values for the fine-tuned features, then this (together with the observer selection effect) explains why our universe is fine-tuned.*

To understand the general form of this explanation, consider the roll of two dice, one white and one black. Specifically consider the roll 'white 3 black 5' (W3B5). The dice are fair, so the probability of W3B5 on any one roll is  $1/36$ . If the dice are rolled many times, then the probability that W3B5 will be rolled at least once increases. (The probability of W3B5 being rolled on any particular roll remains at  $1/36$ ). If the dice are rolled 36 times, then the chance that W3B5 is rolled at least once is about  $2/3$ . If the dice are rolled one thousand times, then the chance of getting W3B5 is almost certain (Hacking 1987). So if there were many rolls we would expect to see W3B5 somewhere in the sequence of rolls. This is the basis of the explanation. Now consider an added complication. Imagine that there is an apparatus associated with the roll such that the dice are only visible to us if they roll W3B5.

Imagine that we see the roll W3B5. At this point we can ask: why did we see the roll W3B5? One answer is that W3B5 is the only roll we could have seen, so given that we saw a roll, it must have been W3B5. This answer is based on the observational selection effect. Self-evidently, we can only observe situations that allow for our presence as observers. However, independently of the observer selection effect, there are some expectations that we have about the roll based on the probability of W3B5. If there were only one roll of these dice, then we would expect it to be W3B5 with a probability of  $1/36$ . If there were one thousand rolls, we would expect with almost certainty at least one roll to be W3B5. So, as the number of rolls increases, so too does the expectation that we would see the dice (i.e., when they roll W3B5). The multiple universe explanation has been criticised (Dowe 1999; White 2000). There are three important criticisms. These criticisms are closely related, but I will consider them separately.

11.2.3 The probability of this fine-tuned universe and confirmation theory

In confirmation theory, explanations that raise the probability of events are confirmed by those events. If there are many and varied universes, this raises the probability that *some* universe will be finely-tuned. But, it does not raise the probability that any *specific* universe is finely-tuned. In particular, it does not raise it for *this* universe (White 2000).<sup>175</sup> Given that the event we are considering is that *this* universe is finely-tuned and further that the probability of this event is not increased by the existence of many other universes, then the hypothesis that there are many universes is not confirmed by this finely-tuned universe. So using confirmation theory, the fine-tuning of this universe does not confirm the hypothesis that there are many universes.<sup>176</sup>

Notice that the probability of *some* universe being finely-tuned is increased by the existence of many universes. So, arguably, we could use the event 'some universe is finely-tuned' to confirm the hypothesis that there are many universes. But critics of the MU explanation argue that to explain why *some* universe is fine-tuned is not the same as explaining why *this* universe is fine-tuned. White argues that this approach fails to consider the total evidence available; we cannot ignore the fact that it is *this* universe that is finely-tuned, not simply *some* universe (White 2000) 264.

However, the fact that the multiple universe explanation does not raise the probability of this universe being finely-tuned is not a fatal weakness. All we need do is relinquish our expectation that explanations should raise the probability of the events they explain. If we accept the reality of indeterminism, then some events will be ontically improbable. Using the conformity maxim, we do not want our explanations necessarily to raise the probability of the events they explain. We want the epistemic probabilities generated by

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<sup>175</sup> Here *this* universe is understood as referring to the universe we are in. The problems associated with the concept of 'this universe' are further considered by Manson and Thrush (Manson and Thrush 2003).

<sup>176</sup> White has a similar concern regarding the explanation that involves every logically possible universe. He argues that the existence of every logically possible universe explains (by raising the probability to 1) why *some* universe is fine-tuned but, *contra* to Hacking (Hacking 1987), he argues it does not explain (by raising the probability) why *this* universe is fine-tuned (White 2000).

our explanations to match ontic probabilities in the world. I contend that the multiple universe explanation together with the observer selection effect is a reasonable explanation of the fine-tuning, *if there are multiple universes*.

To understand this, imagine watching a series of rolls of a pair of dice. (All the rolls are visible.) As we watch we notice that the 7<sup>th</sup> roll was W3B5. The fact that there are many rolls explains why we saw this roll. But it does not explain why W3B5 occurred on the 7<sup>th</sup> roll. However I am content to leave this unexplained. Further, if we impose the observer selection effect that we employed above, namely that the only roll that we can see is W3B5, then this explains why we see it. To address White's concern here, White is concerned that the probability that the 7<sup>th</sup> roll is W3B5 has not been increased by the existence of many rolls. He is correct; the probability of W3B5 on any single roll (including the 7<sup>th</sup>) is still 1/36. But we do not need to increase the probability that the 7<sup>th</sup> roll was W3B5. We can adequately explain why we saw W3B5 by the fact that there are many rolls and (using the observer selection effect) W3B5 is the only roll we could have seen. However, this is only a good explanation of seeing W3B5 if there are many rolls. This leads to the second criticism.

#### *11.2.4 The inverse gambler's fallacy*

That this fine-tuned universe is improbable gives us no reason to believe that there are many universes. If we have evidence that an improbable (chance) event has occurred and we use this evidence to conclude that there must have been very many similar (chance) events preceding it, then we make an error of reasoning that has been called the *inverse gambler's fallacy* (Hacking 1987). To understand this, imagine that we have just walked into a room and we see a pair of fair dice roll W3B5. This event has a probability of 1 in 36, and for our purposes, let us consider this to be an improbable event. If we conclude that there must have been a long series of rolls preceding this event *because it is improbable*, then we commit the inverse gambler's fallacy. Similarly, if we assume that this universe is improbable, and based on this assumption, we conclude that there must be many other universes, then we commit the same fallacy.

The charge of falling into the inverse gambler's fallacy here has interesting implications

in the fine-tuning debate. Notice that the inverse gambler's fallacy is related to chance situations. The basic point is that if one improbable *chance* event has occurred we cannot assume that other *chance* events have occurred, to 'balance it out'. But one of the central points at issue in the fine-tuning debate is whether the fine-tuning is due to chance. Notice that the inverse gambler's fallacy is only a fallacy in chance situations. So an assumption about chance is being made to invoke it, and that could beg the question.

#### *11.2.5 Cause and effect problems*

Finally, I have criticisms related to cause and effect. Recall Humphreys' Paradox, where we cannot understand effects with physical probabilities of having been caused by various causes. We can understand these as epistemic probabilities, but not as physical or ontic probabilities. Causes can give effects an ontic probability, but effects cannot give causes an ontic probability.<sup>177</sup> A fair lottery can give a single ticket an ontic probability of winning which might be very small. But the winning ticket does not thereby give the lottery a very small ontic probability of being fair. The situation is clear in the case of ontic probability, but problems appear with epistemic probability. The relevance criterion in confirmation theory stipulates that the probability of a hypothesis, that increases the probability of the evidence, is itself increased. This favours the rejection of chance, when the chance hypothesis gives the evidence a small probability. In the case of the lottery we seem to be required to confirm the hypothesis that the lottery was *not* fair, but this does not seem reasonable.<sup>178</sup> This error can be considered as a probabilistic version of the fallacy of affirming the consequent.<sup>179</sup> Returning to the multiple universe argument, if there were many universes (and accepting the observer

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<sup>177</sup> There is potential here for a 'backwards causation' response to Humphreys' Paradox.

<sup>178</sup> For Mackie's defence of the relevance criterion, see (Mackie 1969) 39-40.

<sup>179</sup> Sober makes the similar point that there is no probabilistic version of modus tollens (Sober 2003) 34.

selection effect), then we would expect to see a finely-tuned universe. But just because we see one, it does not imply that there are many universes.<sup>180</sup>

#### *11.2.6 The die roll analogy and an 'immaterial chance set up'*

Much of the philosophical literature examining the strength of the multiple universe explanation uses the analogy of a roll of dice. This analogy is useful in determining what is, and what is not, appropriate with respect to probabilistic argument. However, there is a danger with the use of the dice analogy. The dice analogy implicitly assumes circumstances that are not necessarily appropriate in the case of the universe. We know what dice are. We know how they are used. We roll them on a surface and one of the faces lands uppermost. We understand why a '3' lands uppermost on any particular roll because it is one of the possibilities and it happened to occur. We understand this because of the material existence of the die and the surface on which it is rolled. But in the case of the universe, we are attempting to *explain* material existence. So, as noted by Mellor, there can be no *material* chance set up involved in the explanation (Mellor 1973, 2003). Any chance set up that we use to explain this finely-tuned universe must be *immaterial*. Mellor is unhappy with the idea of an immaterial chance set up. Perhaps quantum theory can provide such a set up. I will examine this possibility later.

#### *11.2.7 The anthropic principle versus anthropic reasoning*

The existence of this universe is not evidence for the existence of other universes. However *if* many other universes exist, then this fact (together with the observational selection effect) explains why this universe is finely-tuned for life. The fact that many other universes exist increases the probability that *some* universe is finely-tuned for life and the observational selection effect picks out *this* universe, because we could not observe any other.

We cannot use the observational selection effect (the anthropic principle) alone to explain the fine-tuning of this universe *by postulating multiple universes*. The anthropic

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<sup>180</sup> Some may argue this criticism only holds for the *material* conditional (Fumerton 1992).

principle is not the *reason* that there are other universes. But we can use *anthropic reasoning* to motivate a search for them. Anthropic reasoning is a valid form of investigation, as illustrated by Fred Hoyle searching for and finding the resonance level of carbon. Given what was known at the time about carbon formation, it would have been unlikely for our universe to contain the amount of carbon that it does. So Hoyle predicted a mechanism that made it more likely that carbon could form. Hoyle looked for such a mechanism and found a resonance level that increased the probability of carbon formation (Barrow and Tipler 1988) 252. Similarly anthropic reasoning can be used to motivate the search for other universes. It can also motivate us to consider the existence of a chaotic or quantised reality, or a God.

### 11.3 Design

One prominent explanation of the fine-tuning is that God was responsible. This is a version of the design argument, the standard presentations and criticisms of which I will bypass, but I will make some comments of specific relevance. First, consider one possible characterisation of the design argument.

*Take some feature of the universe X.*

*If there were a designer who wanted X, then we would expect to see X.*

*We see X therefore we conclude that there is a designer who wanted X.*

But just because we see X does not give us reason to believe that there is a designer. To do so would be to fallaciously affirm the consequent. If we have independent reasons for believing in God, then we can use God to explain the fine-tuning. But we cannot use the fine-tuning to argue for the existence of God.<sup>181</sup> Advocates of the design argument recognise this problem. In response, Dembski suggests that we must be able to specify the feature in question *independently* of its existence. But as I have argued, this is not possible in the case of the fine-tuning of the universe. Without the possibility of

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<sup>181</sup> This directly parallels the criticism of the multiple universe explanation. We cannot use the fine-tuning to argue for the existence of many universes, but if we have independent reasons for believing in many universes, then we can use them to explain the fine-tuning.

independently specifying the apparently designed feature, all we can do is fabricate a description.

Further there are anthropocentric concerns here. Notice that this style of argument can be used for any feature of existence. Imagine a universe filled only with dust. We can use the design argument to argue that this ‘Dusty Universe’ was designed by a God who loved dust. (Notice also that we can use the design argument to explain the ‘apparent’ spontaneous decay of atoms, if we think that God could have a reason for wanting the atom to decay at that particular time.) This form of argument can be used to argue for a designer that wanted *whatever we happen to find*.

Presumably advocates of the design argument do not see it to be fallaciously affirming the consequent. Manson characterises modern design arguments as typically employing a ‘probabilistic logical apparatus’ (Manson 2003) 5. However, Manson distinguishes several different probabilistic approaches. He characterises Swinburne’s version of the argument as ‘robustly’ Bayesian, and he notes that other versions infer design by using Dembski’s explanatory filter. Manson characterises Dembski’s approach as similar to Ronald Fisher’s model of scientific inference based on ‘significance tests’ (Fisher 1959). Alternatively, Elliot Sober argues that the design argument is not Bayesian but an argument from ‘likelihoods’. Sober’s position is important because if he is correct, then the argument is not concerned with determining whether design is more probable than other hypotheses (Sober 2003) 30. While Sober’s comments are relevant, I will focus on Swinburne’s Bayesian version of the design argument.

Finally, one traditional criticism of the design argument is that while it might support the general notion of design, it fails to support the specific nature of the designer. In the West, the design argument is traditionally presented as evidence for the existence of the Christian God. However critics argue that all that the design argument achieves, if it

achieves anything, is to support the idea that some being designed the universe. However, here I will take the design argument to refer to the traditional Christian God.<sup>182</sup>

### *11.3.1 Swinburne's argument*

Consider Swinburne's description of the fine-tuning.<sup>183</sup>

Not all initial conditions or laws of nature would lead to, or even permit, the existence of human bodies at some place or other at some time or other in the universe. So we may say that the universe is 'tuned' for the evolution of human bodies if the laws and initial conditions allow this to occur (in the sense that they fully cause this evolution if the laws are deterministic, or make it significantly probable if the laws are probabilistic). If only a very narrow range of laws and initial conditions allow such evolution, then we may say that the universe is 'fine-tuned' for this evolution (Swinburne 2004) 172.

Swinburne's argument is as follows. Consider two different situations; one in which the fine-tuned values are the result of chance and another where they are the result of design. Consider the probability that the constants and initial conditions held the values that allowed for life, conditional on both chance and design. The central idea of the argument is that the fine-tuning of the universe is improbable as a result of chance, but if we assume there is a God who planned our existence, then the fine-tuning is not improbable. Using confirmation theory Swinburne argues that the fine-tuning is evidence for God, because the probability of it conditional on God is greater than the probability of it conditional on chance. Let us consider this in more detail.

I begin with Swinburne's definitions of the hypothesis of theism *h*, background knowledge *k*, and new evidence *e*. Swinburne defines the hypothesis of theism as

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<sup>182</sup> I do not consider the Neoplatonic God as presented by (Leslie 2003) or 'ultimate purpose' as presented by (Davies 2003).

<sup>183</sup> I present Swinburne's argument as it appears in *The Existence of God* (Swinburne 1991). Recently Swinburne has published a second edition (Swinburne 2004). There are some changes to the language and details of his argument; however I take it to be essentially the same. The 1991 argument is concise and largely self-contained (as an appendix) while the 2004 argument is incorporated into the body of the book. For this reason I will use his argument as presented in 1991. However, where he has made significant changes or refinements to his argument or position these will be incorporated into the analysis.

follows: “there exists a person without a body (i.e. a spirit) who is eternal, is perfectly free, omnipotent, omniscient, perfectly good and the creator of all things.” He calls this person God (Swinburne 1991) 8. In *The Existence of God* Swinburne independently argues that God “would both be able and have reason to produce intelligent organisms” (Swinburne 1991) 303. It is important to note that this independent argument is central to Swinburne’s fine tuning argument. If God is unable or has no reason to produce intelligent organisms, then Swinburne’s fine-tuning argument fails. For our purposes here I concede that, if God exists, God would both be able and have reason to produce intelligent organisms. Swinburne defines background knowledge  $k$  as “the existence of a universe governed by some laws of nature or other” and new evidence  $e$  as “laws and boundary conditions such as to make likely the evolution of intelligent organisms” (Swinburne 1991) 303.<sup>184</sup> With these definitions in mind, let us look at Swinburne’s argument.

For the reasons which I have given, a God would both be able and have reason to produce intelligent organisms. ... He could do so either directly (as most, but not all, thinkers before Darwin supposed that he had done) or indirectly, making the world with boundary conditions and scientific laws such as to give rise to intelligent organisms. All the evidence accumulated by scientists over the past 200 years shows overwhelmingly that present day intelligent organisms (i.e. human and animal bodies) evolved gradually from inanimate matter in accord with scientific laws over thousands of millions of years. So God did not produce intelligent organisms directly. But if all the evidence is that the occurrence of boundary conditions and laws such as to permit and make probable the evolution of intelligent organisms are *a priori* (that is, unless there is a God) very unlikely, then (by the pattern of argument used extensively in this book) that is evidence that God brought them about, and thereby indirectly brought about the existence of intelligent organisms. He made an intelligent organism-producing universe. With  $e$  as laws and boundary conditions such as to make likely the evolution of intelligent organisms,  $h$  as the hypothesis of theism,  $k$  as the existence of a universe governed by some laws of nature or other,  $P(h/e.k) > P(h/k)$ , indeed  $P(h/e.k) \gg P(h/k)$  (Swinburne 1991) 303.

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<sup>184</sup> For the definitions in the second edition, see page 7 for theism ( $h$ ), and page 189 for new evidence ( $e$ ) and background knowledge ( $k$ ) (Swinburne 2004). Although slightly different these definitions do not change the substance of the argument in any way relevant to this thesis.

### *Explaining the Fine-Tuning*

Swinburne begins by comparing the probability of the fine-tuning conditional on chance, with the probability of fine-tuning conditional on God. Swinburne argues that the probability of the fine-tuning conditional on chance is very small, but that the fine-tuning is 'much to be expected' if there is a God (Swinburne 1991) 311. So he claims that the probability of the fine-tuning is greater conditional on God, than conditional on chance:  $P(e/h.k) > P(e/k)$ . Then he refers to 'the pattern of argument used extensively in this book', this is the inference central to confirmation theory.

*Since  $P(e/h.k) > P(e/k)$  therefore  $P(h/e.k) > P(h/k)$ .*

*Since the probability of the evidence given the hypothesis is greater than the prior probability of the evidence therefore the probability of the hypothesis given the evidence is greater than the prior probability of the hypothesis.*

In other words, since the hypothesis of theism 'explains' the evidence of fine-tuning, therefore the evidence of fine-tuning 'confirms' the hypothesis of theism. Swinburne concludes that the fine-tuning of the universe is evidence for the existence of God. Note that in (Swinburne 2004) Swinburne refers to 'human bodies' while in (Swinburne 1991) he refers to 'intelligent organisms'. I see no reason to restrict the argument to human bodies, so I will refer to 'intelligent organisms'.

#### *11.3.2 The contingency of the existence of intelligent organisms*

Setting aside my concerns about confirmation theory considered previously, there is a problem associated with the fact that given the fine-tuning, the existence of intelligent organisms is not *certain*.<sup>185</sup> In the first passage quoted Swinburne considers both deterministic and probabilistic laws, and notes that if determinism is true, then the fine-tuning 'fully causes' the existence of human bodies (intelligent organisms). But elsewhere Swinburne appears to assume that determinism is not the case (Swinburne 2004) 189. So I take Swinburne's position to be that the fine-tuning makes the existence of human bodies (intelligent organisms) 'significantly probable'. However, regardless of the probability, it is the *contingency* of the existence of human bodies (intelligent

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<sup>185</sup> My argument concerning the problem of contingency is based on (Wood 2002).

organisms) that causes Swinburne's argument difficulty. Swinburne's argument relies on the assumption that God "would both be able and have reason to produce intelligent organisms" and here I grant that this is a reasonable assumption. But if God is able and has reason to produce intelligent organisms, then why is the existence of intelligent organisms not certain? If God is as Swinburne conceives God to be, then intelligent life should be *certain*. This is a problem for Swinburne's argument. To be clear, let me restate it.

*God is omnipotent.*

*God is able and has reason to produce intelligent organisms.*

*If God is omnipotent and has reason to produce intelligent organisms, then the existence of those organisms is certain.*

*But, given the fine-tuning, the existence of intelligent organisms is not certain.*

Here it is assumed that the fine-tuning of the laws and boundary conditions does not ensure the existence of intelligent organisms. This means that the probability of the existence of intelligent organisms given the fine-tuning is not 1. There is a great variation in the literature about the probability of the existence of intelligent life given the fine-tuning of the universe.<sup>186</sup> To illustrate this, consider the evolution of some form of intelligent organism, possessing what we call 'consciousness'. While Davies believes that the evolution of consciousness is 'assured' (Davies 2003) 153, Gould believes that consciousness was a 'quirky evolutionary accident' (Gould 1987) 431. It would appear that the probability of the existence of intelligent organisms relates to many contingent events after the fine-tuning, such as the emergence of self-replicating entities (e.g. DNA or its precursor), the subsequent evolution of complex life, and specifically the evolution of intelligent organisms. Quantification of this probability is not necessary for our purposes. The important point is that *the probability of intelligent organisms given the fine-tuning is not 1*, and on this point (excluding Davies) there is general agreement in the literature.

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<sup>186</sup> For examples of this discussion, see (Dawkins 1991; Barrow and Tipler 1988; Gould 1987).

Swinburne states that there is "a very considerable, but not unanimous, scientific view that the laws and initial conditions of our universe make it very probable that human life [intelligent organisms] will evolve in more than one place in the universe, and animal life will in quite a number of places" (Swinburne 2004) 189. This probability may be very high, but even the very high probability of the existence of intelligent organisms is not sufficient to avoid the problem. Swinburne argues that God would be able and have reason to produce intelligent organisms. *Swinburne does not argue that God would be able and have reason to facilitate the very probable production of intelligent organisms.* Further note that Swinburne's definition of 'fine-tuning' is consistent with this contingency. The fine-tuning, as defined by Swinburne, does not make *certain* the existence of intelligent organisms. So his position is consistent with the assumption that the probability of the evolution of intelligent organisms given the fine-tuning of the universe is not 1.

*$P(i/e.k) \neq 1$ , where  $i$  is the existence of intelligent organisms.*

### *11.3.3 The problem of contingency*

I call this the *problem of contingency* and it parallels the *problem of evil*. Given the fine-tuning of the universe, the existence of intelligent organisms *is not certain*. If God is omnipotent, omniscient and is able and has reason to produce intelligent organisms, then the existence of intelligent organisms *is certain*. The existence of intelligent organisms cannot be both certain and not certain, so there is a problem.

First consider God's omnipotence. I accept Swinburne's definition of omnipotence. God is able to do all that is logically possible (Swinburne 1991) 8. I see no reason why ensuring the existence of intelligent organisms is logically impossible. If God can do all that is logically possible, then there is no reason why God could not ensure the existence of intelligent organisms. But perhaps there is some logical limitation on God here similar to the limitation with respect to the existence of evil. God, who does not want evil but also wants us to have free will, cannot ensure that there will be no evil in the

world. God cannot ensure the absence of the evil produced by our free will. So, perhaps God wants intelligent organisms but cannot ensure their existence for similar reasons.<sup>187</sup> However, while this limitation may be reasonable in the case of the *free will* of intelligent organisms, I cannot see an equivalent limitation to prevent God ensuring the *existence* of intelligent organisms. The limitation in the case of evil is due to the nature of free will. God could only be prevented from ensuring the existence of intelligent organisms if 'free will' somehow exists in the evolution of the universe and/or the evolution of life. But neither the universe, nor non-conscious life is traditionally considered to have free will.<sup>188</sup> So I cannot see how an omnipotent God could be logically prevented from ensuring the existence of intelligent organisms.

Now consider omniscience, and recall that I grant here that "God is able and has reason to produce intelligent organisms." Swinburne defines God as knowing 'whatever it is logically possible' for God to know (Swinburne 1991) 8. So assume that God knows what God wants. If God does not know what God wants, then God is not omniscient.<sup>189</sup> Or perhaps God knows that God wants intelligent organisms but does not know how to ensure their existence. But if that is the case, then God is not omniscient.

So far, I have assumed that the existence of intelligent organisms is not certain. But this may be wrong. Although there is general agreement (excluding Davies) that the existence of intelligent organisms is not certain, perhaps it is. Perhaps given the fine-tuning, *some* form of intelligent organism would be certain to arise.<sup>190</sup> The idea that God ensured the existence of *some* form of intelligent organism is initially attractive, but on

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<sup>187</sup> This suggestion was made by an anonymous referee of the paper (Wood 2002).

<sup>188</sup> The functioning of indeterminism will be considered later.

<sup>189</sup> We should not be distracted by God's free will. God would not know what God wanted before God made a decision, but once God made a decision, God would know what God wanted.

<sup>190</sup> Swinburne moved from 'intelligent organisms' in 1991 to 'human bodies' in 2004. By this move, he has denied himself the option of arguing that *some* type of intelligent organism was certain to exist, and it is much more difficult to argue that human bodies were certain to exist. In fact he seems to accept that the existence of human bodies is not certain. "It may be that, given the initial conditions of the universe in all their detail, the laws of nature as such do not necessitate the evolution of human bodies, only make it quite probable" (Swinburne 2004) 189.

reflection it is problematic. It is in tension with the assumption that God would make the "best possible world", or at least "a very good world" (Swinburne 2003) 107-108.

Although my own capacities are limited, it seems logically possible for God to decide which of the *possible* intelligent organisms would be the best *actual* ones. So it appears that *God would have been able to choose*. God's ability to choose also holds for the situation in which two potential intelligent organisms are literally equal in God's contemplation. Given God wants the existence of at least one intelligent organism, God has two choices. Either God decides to choose one, or God leaves the decision to chance, knowing that one intelligent organism will certainly exist. But for what purpose would God leave the decision to chance? Without a reason not to choose, God would choose, thereby making one intelligent organism's existence certain.

To illustrate the problem of contingency further, confirmation theory can be used to compare Swinburne's God (*h*) with any one of three others (*h\**): 1. a non-omnipotent God, 2. a non-omniscient God, and 3. a God that is indifferent to the production of intelligent organisms. For argument sake, assume that the prior probabilities of Gods are equal. Now the probability of the evidence (*c*) *the fine-tuning does not ensure the existence of intelligent organisms* is greater, conditional on any one of the other Gods, than conditional on Swinburne's God. And since  $P(c/h^*.k) > P(c/h.k)$  iff  $P(h^*/c.k) > P(h/c.k)$  the evidence confirms the other three Gods more than it confirms Swinburne's God.<sup>191</sup>

For the sake of argument, assume that God is omnipotent, omniscient and was able and had reason to produce *our type* of intelligent organisms, (i.e., human bodies). Is there any way to avoid the problem that our existence seems to be contingent? I consider three ways to resolve the problem: (1) determinism, (2) miraculous divine intervention and (3) non-miraculous divine intervention. The problem is that the probability of the existence of intelligent organisms is not 1.  $P(i/e.k) \neq 1$ , where *i* is the existence of intelligent organisms. This probability is an epistemic probability. All three solutions to the

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<sup>191</sup> A full version of this argument is presented in (Wood 2002). I imagine Swinburne's response would be to argue for the greater prior probability of the traditional theistic God, see (Swinburne 2003) 107.

contingency problem considered here claim that this epistemic probability is *erroneous*. The solutions are all based on the assumption that the ontic probability of the existence of intelligent organisms is in fact 1,  $P(i/e.k)=1$ . But each solution supports this assumption differently.

#### *11.3.4 Determinism*

The first solution assumes physical determinism: given the fine-tuning it was certain that intelligent organisms would exist. So although the epistemic probability is less than 1, the ontic probability is in fact 1. This means that all the apparently contingent events that have occurred after the fine-tuning and have led up to the existence of intelligent organisms were in fact certain to occur *because* of the fine-tuning. The formation of planets suitable for the appearance of life, the occurrence of self-replicators (DNA), the evolution of complex life, and the emergence of intelligent organisms are in fact determined by the fine-tuning of the universe. If the fine-tuning made certain the existence of intelligent organisms, then this solves the problem of contingency.

But determinism as a possible solution is unsatisfactory for three reasons. Firstly, current scientific theory holds that determinism is not universal. Indeterminism exists at least at the quantum level and possibly more widely. If the deterministic solution to the problem of contingency is to succeed, the process that led to the certain existence of intelligent organism must be independent of indeterminism in the world. This seems unlikely to be the case. Secondly, the deterministic solution has the potential to remove the contingency of the fine-tuning itself, and thus remove the need for a designer. Consider the possibility that determinism is true and that the existence of intelligent organism is certain given the fine-tuning. If this is the case, then all the apparently contingent events that have led to the existence of intelligent organisms in fact happened of necessity. So the ontic probability of the existence of intelligent organism is 1, and our epistemic probability of the existence of intelligent organisms is erroneous. This is because we do not understand the nature of the situation. However, if we do not understand with respect to our own existence, perhaps we are equally mistaken with respect to the apparent contingency of the fine-tuning. If the deterministic solution is accepted for the existence of intelligent organisms, then the same argument can be used to explain the fine -

tuning itself. It appears to us that the fine-tuning is contingent, but if we were mistaken about the apparent contingency of the existence of intelligent organisms given the fine-tuning, then we may also be mistaken about the contingency of the fine-tuning itself. If there is a universe at all, then perhaps the fine-tuning is necessary for (as yet) unknown reasons. If it is the only option, then we do not need a designer. We may still be interested to know why the fine-tuning was the only option, but this form of necessity is not usually explained by design. Thirdly, some find determinism unsatisfactory because it does not allow for (libertarian) free will. While Swinburne acknowledges the possibility of determinism and the existence of human bodies being 'fully caused' by the fine-tuning, he does not endorse this option. His reasons may relate to the possibility that indeterminism is an avenue for the operation of libertarian free will (Swinburne 2004) 170. For these reasons, determinism is not a good solution to the problem of contingency.

### *11.3.5 Miraculous divine intervention*

The second solution involves God acting through miraculous divine intervention. God acting through miracles is in *contravention* of the natural order. In this scenario, God fine-tunes the universe to allow for the existence of intelligent organisms, but this is not the end of the process. God continues to intervene in the natural order, through the evolution of the cosmos and life on earth, to ensure the existence of intelligent organisms. God does this by intervening at the appropriate moment to facilitate, for example, the structure of our solar system, the emergence of life, the rise of the mammals, and so on. Here the fine-tuning itself does not ensure the existence of intelligent organisms. It simply allows for the possibility. The fine-tuning together with a series of later interventions ensures the existence of intelligent organisms. I call this *miraculous* divine intervention, because God's intervention results in the world developing differently from the way it could have developed without the intervention.

This solution is also unsatisfactory because it contradicts the assumption that God is omnipotent and omniscient. If God is both omnipotent and omniscient, then it seems unnecessary for God to 'tinker' with creation along the way. God could simply start the universe off in such a way as to ensure the existence of intelligent organisms. Now

there may be a logical reason that the original cosmic fine-tuning of the universe as a whole could not ensure the existence of intelligent organisms but it is not obvious. So ongoing intervention would seem to imply that God is either not omnipotent or not omniscient.

Further, Swinburne states that God fine-tuned the universe and left it to proceed independently.

All the evidence accumulated by scientists over the past 200 years shows overwhelmingly that present day intelligent organisms (i.e. human and animal bodies) evolved gradually from inanimate matter in accord with scientific laws over thousands of millions of years. So God did not produce intelligent organisms directly (Swinburne 1991) 303.

I take the use of the phrase “in accord with scientific laws” to imply that Swinburne believes that God did not take action in *contradiction* of the laws, and the statement “God did not produce intelligent organisms directly” to mean that God did not intervene specifically in Earth’s history to ensure the evolution of intelligent organisms. So, according to Swinburne in 1991, while God fine-tuned the universe, he did not intervene to affect the evolution of life *after* the fine-tuning. However, as we will see, more recently his position may have changed with respect to ongoing intervention.

#### *11.3.6 Non-miraculous divine intervention*

The third solution to the problem of contingency involves God interacting with the world in a significantly different way. I call this non-miraculous divine intervention.<sup>192</sup> Under this option, God created the universe based on laws, but there is an aspect of indeterminism in the laws. The indeterminism in the laws enables God to intervene, from time to time, in the normal workings of the universe and to *dictate* the outcome of these ‘indeterministic’ laws. Thus indeterminism would be *real* if God did not intervene and *apparent* if God did intervene. This allows God to direct these laws in such a way as

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<sup>192</sup> A concept similar to non-miraculous divine intervention, was proposed by Popper and Eccles. This involved the manifestation of personal free will through quantum indeterministic processes in the brain (Popper and Eccles 1977).

to ensure the existence of intelligent organisms. Thus the fine-tuning of the laws and initial conditions can be understood as 'indeterministic' outcomes *determined* by God. After the fine-tuning, God then intervenes in other indeterministic processes to ensure the existence of life, and intelligent organisms. So the universe does unfold "in accord with scientific laws" but the indeterminism of the laws allows God to ensure the existence of intelligent organisms without contravening those laws.

So the existence of intelligent organisms could be certain even though, as Swinburne says, 'intelligent organisms evolved gradually from inanimate matter in accord with scientific laws'. With this solution, the fine-tuning does not ensure the existence of intelligent organisms; it merely allows for their possibility. Subsequently, God acts through the indeterministic aspects of laws to produce, *apparently* indeterministically, the *certain* existence of intelligent organisms. The fact that the probability of intelligent organisms given the fine-tuning does not equal 1 ( $P(i|e.k) \neq 1$ ), does not count against the design argument. Due to the way God interacts with the world, all acts of God will be manifest through the indeterministic aspects of natural laws.<sup>193</sup>

#### *11.3.7 Non-miraculous divine intervention and freewill*

Why would God choose to act in such a way? If God is omnipotent, then why use such an apparently unnecessary method to produce intelligent organisms? There may be a good reason. Assume that God wanted intelligent beings with *free will*. Perhaps 'apparent indeterminism' is the *only* way that God can create a universe (governed by laws) that *allows for* the existence of free will. In such a system, 'the will' would control the outcome of apparently indeterministic processes in the brains of 'humanly free

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<sup>193</sup> This possibility has been noted previously in the literature. Dowe has considered the implications of indeterminism for God's providence. He characterises providence as "God's continuing action whereby he preserves creation and directs it according to his purposes" and he states that if "chance does lead to meaningful consequences, ... God causes that chance" (Dowe 1997). The idea of God using indeterminism to direct the course of evolution has also been suggested by Kenneth R. Miller (Miller 1999).

agents'.<sup>194</sup> This explains why there must be indeterminism at least in their brains, but it does not explain the existence of indeterminism in the universe outside those brains. But again there could be a good reason for this as well. Perhaps it was structurally *necessary* for God to build indeterminism into the very fabric of the universe, including the fine-tuning itself, *because this allows for the indeterminism in the brain* that in turn allows for free will. If we assume that God interacts with the world through apparent indeterminism in natural laws, and through this mechanism *ensures* the existence of intelligent organisms, then we avoid the inconsistency of God wanting intelligent organisms but not ensuring their existence.<sup>195</sup> So we have avoided the problem of contingency. We have done this by assuming that the existence of intelligent organisms is certain, and facilitated through God directing apparently indeterministic processes. The 'indeterminism' makes the existence of intelligent organisms *appear to us* to be contingent when it is in fact necessary.

### *11.3.8 Probabilistic limits on non-miraculous divine intervention*

I have presented two forms of divine intervention, miraculous and non-miraculous. I contend that miraculous divine intervention is not a viable option. But non-miraculous divine intervention may be. However there is an important limit on God's ability to intervene. The limit is that God's intervention must be 'in accord with scientific law'. If it were not in accord with scientific law, then it would be *miraculous* divine intervention. But what does it mean for God's intervention to be in accord with scientific law? In the second edition of *The Existence of God* Swinburne suggests that "God can guide the way in which the probabilistic laws operate so as to ensure that human bodies do evolve, without in any way preventing their operation, simply by

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<sup>194</sup>The concepts of free will and specifically 'humanly free agents' are explored by Swinburne in Chapter 9 of *The Existence of God* (Swinburne 1991), and the idea of quantum indeterminism as a vehicle for free will is explored by Popper and Eccles in *The Self and its Brain* (Popper and Eccles 1977).

<sup>195</sup> If this restriction is a *logical* one then this impacts on the previous discussion of omnipotence. If God wants organisms with free will and the only logically possible way to achieve this is to build indeterminism into the structure of the universe, then the fact that the existence of intelligent organisms seems contingent is not a limit on God's omnipotence.

ensuring that the most probable outcome does occur" (Swinburne 2004) 189.<sup>196</sup> While to a certain extent Swinburne is correct that ensuring the 'most probable' outcome does not prevent the operation of the law, this suggestion needs to be handled with care. For instance, if God *always* ensures the most probable outcome, or even just ensures the most probable outcome *too often*, then God would in fact be *preventing* the operation of the law. To understand why, remember that the law is probabilistic. So the law *implies a probability distribution*. God can ensure that a very probable event occurs, or indeed can ensure that a very improbable event occurs, as long as the occurrence of the event does not affect the probability distribution of events subject to the law. If the outcome does affect the probability distribution, then God is not acting in *accord* with the law but in *contravention* of it. Consider the radioactive decay of an atom. God can control the 'spontaneous' decay of one atom, by making it decay at a certain time, but if God acted such that the *empirical frequency distribution* of the decay of all atoms of that element changed, then God would not be acting 'in accord with scientific law' but in *contravention* of it. As long as the frequency distributions of events within indeterministic systems are consistent with the indeterministic laws, God can act through indeterminism without contravening those laws.

How can we determine whether an outcome affects the probability distribution of a law? First we need to know the distribution. If the probability distribution is uniform (say), then all possible events will have equal probability of occurring. So no single event will contradict this probability distribution. In general, any single event that had some positive probability in the distribution does not contradict the distribution.<sup>197</sup> However, we need to be careful when we consider many outcomes. If a *series* of outcomes determined by God contradicts the probability distribution associated with those outcomes, then God is not acting in accord with the law but in contravention of it. So God is limited in how much intervention is possible. God can intervene in the workings

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<sup>196</sup> Recall that in the first edition of *The Existence of God* Swinburne seemed to assume that God did not intervene in the natural order to ensure the existence of human bodies (Swinburne 1991) 303.

<sup>197</sup> If an event occurs that has a probability of 0 (i.e., it was impossible based on the probability distribution), then this event does contradict the probability distribution.

of indeterministic laws, but not to the extent that the overall shape of the probability distribution of events associated with those laws changes. Interestingly this might explain why the Universe is so vast. One life-allowing planet in a vast Universe does not contravene the probability distribution of life-allowing planets, and thus God can ensure the existence of such a planet without contravening the laws.

#### *11.3.9 Empirical indistinguishability and metaphysical scepticism*

But if God intervenes in accord with indeterministic scientific law, then we could not distinguish a *real* indeterministic event from an *apparent* indeterministic event determined by God. These events would be *empirically indistinguishable*. This makes the competing explanations, God or indeterminism, indistinguishable. If God acts within the bounds of indeterminism, then we cannot know whether any event is an act of God or due to chance. What are we to conclude from this? One conclusion is that there is no God at all, or perhaps there is a God acting through chance. If we accept the possibility of God acting through indeterminism, then we must remain metaphysically sceptical about this possibility. If God intervenes in accord with indeterministic laws, then there is simply no way to separate this from the normal functioning of such laws.<sup>198</sup>

#### *11.3.10 God and the multiple universe explanation*

The two explanations that we have considered, God and the multiple universe, are completely compatible. God could have created this fine-tuned universe through the process of creating multiple universes and subsequently ensured the existence of intelligent organisms (with the capacity for free will), all by non-miraculous divine intervention.

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<sup>198</sup> In an attempt to resolve the problem of metaphysical scepticism, we could consider the intrinsic probability of the two possibilities, but any conclusion reached would be vulnerable to the criticism of subjectivity.

#### 11.4 An ontic field explanation

Both the "multiple universe" and "God" explanations rely on considerable metaphysical resources, and they have been criticised for this. Swinburne criticises the postulation of other universes (Swinburne 1991) 320, and Scriven criticises the postulation of a supernatural being that designed the Universe (Scriven 1966) 130. I espouse epistemic conservatism, and I avoid metaphysical suppositions if I can do so. Thus I propose a possible explanation that does not rely on either of these considerable metaphysical suppositions. I will attempt to explain this universe as an isolated event.

This explanation is based on the concept of symmetry breaking. It is now widely accepted that fundamental features of the Universe were set by a form of "symmetry breaking mechanism" (Davies 2004) 728. The basic concept is that the strengths of the four forces and the masses of the particles are not fundamental aspects of reality but rather are incidental features. Martin Rees gives this analogy:

Just as the pattern of ice crystals on a freezing pond is an accident of history, rather than being a fundamental property of water, so some of the seeming constants of nature may be arbitrary details rather than features uniquely defined by the underlying theory (Rees 2003) 220.

This idea is usually associated with multiple universe explanations. However, the concept of symmetry breaking can be considered independently. I will use this concept to construct an explanation of this universe that does not assume other universes. The process underlying symmetry breaking *may* produce other universes but these *other* universes are not central to the explanation of *this* universe.

While proponents of multiple universe theories use the idea of symmetry breaking to go on to postulate the existence of many universes I propose a more conservative path. If we can suitably specify some process by which the fine-tuned constants can be generated, then we have a suitable explanation, and do not need to postulate the existence of many other universes. Following Leslie, it is reasonable to suppose that a coin be tossed only once. The existence of a coin does not necessarily imply that the coin is tossed many times (Leslie 1989) 110. Once we understand the nature of the coin, we understand why it landed heads or tails, on a single toss, and we understand this

*without recourse to other tosses. If we require recourse to other tosses to explain this toss, then we have fallen into the inverse gambler's fallacy.*

The situation is the same with a universe. The existence of a universe generating process does not necessarily imply many universes, and once we understand the universe generating process we understand the existence of a single universe. This point, that once we have a suitably specified process, then we have an explanation of a single event generated by that process, is noted by Hacking (Hacking 1987). Following Hacking, I propose that if we can suitably specify the nature of the symmetry breaking process, and so to that extent understand the process, then we have suitably explained the existence of this finely-tuned universe.

#### *11.4.1 Quantum vacuum fluctuation explanation*

Consider the multiple universe explanation first proposed by Edward Tryon, and developed by Richard Gott (Tryon 1990; Gott 1982). Quantum theory postulates the existence of the quantum field.<sup>199</sup> The quantum field is distinct from the material universe. The quantum field can be in various different states.<sup>200</sup> The state we are particularly interested in is the vacuum state. The vacuum state is the lowest energy state of the quantum field. The emergence of matter is a departure from the vacuum state. This process is referred to in quantum theory as a vacuum fluctuation. It is argued that the material universe spontaneously emerged as a fluctuation of the quantum vacuum.

While van Inwagen claims that references to vacuum fluctuations of the quantum field to explain the existence of this universe are not references to the 'familiar' quantum field, but rather some 'analogous' field (van Inwagen 2002) 132, I interpret Tryon as referring to the 'familiar' quantum field when explaining the *material* existence of this universe. 1

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<sup>199</sup> As mentioned at the beginning of this thesis, all the theories associated with the origin of the universe considered here assume that quantum theory is in effect. To be clear this is not an attempt to explain the operation of quantum theory. However, this is equivalent to those who rely on God to explain the existence of this universe without attempting to explain the existence of God.

<sup>200</sup> Just as a hand can be in various states, for example 'a fist' (van Inwagen 2002) 131.

am not in a position to determine which interpretation is correct. However, as we will see, while the familiar quantum field *may* explain the material existence of this universe, arguably, it does not explain the fine-tuning.

So let us consider the existence of an ontic field *possibly* distinct from the familiar quantum field. If the familiar quantum field explains the material existence *and* the fine-tuning of this universe, then the ontic field is not more than the familiar quantum field. However, if the quantum field does not explain the fine-tuning, then the distinct ontic field may do so. In the terminology used previously, we can consider this ontic field as an ontic possibility space grounded in the quantum field or something 'deeper'.

If this universe were the product of a vacuum fluctuation, then it must have certain characteristics. The quantum field is subject to the conservation laws of physics, so, if our universe were to be the product of a fluctuation, then the conservation laws require that the net matter/energy of the universe be zero. This means that the amount of matter in the universe is balanced by the amount of antimatter, and that the positive mass energy is balanced by the negative gravitational energy. Tryon believes this balance to be quite plausible. Thus in answer to the question why this universe exists, Tryon offers "the modest proposal that our Universe is simply one of those things which happen from time to time" (Tryon 1990) 218. In its original formulation this theory has limitations; it does not describe the nature of the 'embedding space' or the development of the vacuum fluctuation (Smith 1986) 82. However Gott suggests that the 'embedding space' was a de Sitter space and that our universe spontaneously emerges from this space via a process of 'quantum tunnelling' (Gott 1982). So now we have a possible explanation of the existence of the material universe.

#### *11.4.2 Does quantum vacuum fluctuation explain the fine-tuning?*

Quantum field theory provides an explanation for how matter can spontaneously arise out of the quantum vacuum, and this may be an explanation of the *material* existence of the universe. But is this an explanation of the *fine-tuning* of this universe? To answer this question we need to divide the fine-tuning into the fine-tuning of initial conditions and the fine-tuning of the characteristics of the fundamental forces and particles.

Broadly speaking, the fine-tuning of the initial conditions is concerned with the amount of mass/energy in the universe. So the vacuum fluctuation does involve this fine-tuning. However this leaves the fine-tuning of the characteristics of the fundamental forces and particles, such as the strengths of the four forces and the masses of the fundamental particles. Could the vacuum fluctuation be an explanation of the strengths of the four forces and the masses of the fundamental particles? The answer to this question depends on whether the process of quantum tunnelling would always produce particles (and energy) with the *same* 'fine-tuned' features, or *different* features. Consider hypothetical 'particle emergences' from the quantum vacuum. Would such emergences always involve particles with the same mass, or with different masses in different hypothetical emergences? To understand this point, consider a die that is rolled. The die represents the ontic field. The rolling of the die represents the emergence of matter/energy. (The numbers of the die do not refer to the *amount* of mass/energy but the *characteristics* of the particles/energy in the emergence.) So, what numbers are on the faces of the die (or alternatively, how many faces does the die have)? If all the faces on the die have the same number, then any emergence of matter/energy would have the same 'finely-tuned' features. But if there are different numbers on the faces of the die, then different emergence events will have different 'finely-tuned' features.

The question is this: do distinct 'particle emergences' always have particles with the same mass or different masses? When Tryon describes vacuum fluctuations where particles spontaneously emerge, his language suggests that these particles always have the same mass and charge (Tryon 1990) 218. He does not mention particles emerging with different masses or charge strengths. This seems to support the idea that the characteristics of emergent particles were fixed. This is equivalent to the die having the same number on every face. If this is the case, then we have explained the material existence of this universe, but we have not explained the finely-tuned features. This highlights van Inwagen's concern that the fluctuation of our *familiar* vacuum cannot be used to explain the fine-tuning.

### *Explaining the Fine-Tuning*

We need to consider the fluctuation of the ontic field. I regard this as equivalent to the notion of symmetry breaking (and perhaps also wave function collapse).<sup>201</sup> Symmetry breaking provides the process for the generation of the finely-tuned features of this world. Quentin Smith explains that there is variation in the parameters of vacuum fluctuation cosmogonies. "Each [vacuum fluctuation] cosmogony implies the existence of an ensemble of worlds that instantiate different initial conditions and values for the fundamental constants" (Smith 1986) 84. For Smith, different hypothetical emergences have different parameter values. This is equivalent to different numbers on each face of the die. If this is the case, then we have explained the fine-tuning of this universe. The explanation is equivalent to explaining the roll of a 3 by saying that '3' is a number on one of the faces of the die and the die rolled 3 by chance.

Here, we have two possibilities. In the first, the same number is on every face of the die. This is equivalent to every symmetry break producing the same fine-tuning. If this is the case, then we have an explanation for why the fine-tuned features occur, and that is because they are the only ones that can occur. But this leaves us wanting to explain why they are the only ones that can occur. This is equivalent to explaining why (say) '3' is on every face of the die. Alternatively, if each face of the die has a different number, then we can explain the roll of a 3 (say) by the fact that it was one of the faces of the die. This is equivalent to different symmetry breaks producing different parameter values. So we can explain why a certain symmetry break had a certain value by pointing to the fact that the parameter value was one of the possible values. But again this leaves us wanting to explain why the symmetry breaks range among these values.

We have the beginnings of an explanation of the fine-tuning, based on the ontic field. We can now work on specifying the nature of the ontic field. This involves specifying what possible parameter values the symmetry break can generate and the probability

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<sup>201</sup> Everett's many worlds interpretation of quantum mechanics is relevant here (Everett 1973). If there exists a superposition of states that includes variation in the force strengths and/or particle masses, then we have an explanation. If a many worlds interpretation is correct, then every possible set of fine-tuned features generated by a symmetry break (wave function collapse) process is actualised by the instantiation of distinct universes.

distribution among those parameter values.<sup>202</sup> This may not be an easy task, but it is well-defined. This is very different from simply stating that any logically possible set of parameter values is possible.<sup>203</sup> Smith suggests that the quantum tunnelling process may produce an infinite number of worlds all with different initial conditions and values for the fundamental constants (Smith 1986) 82. But an infinite number of worlds with different parameters do not necessarily imply every logical possibility. To understand this, recall the example of ice on a pond. There may be an infinite number of ways the water can freeze, but this does not imply the water can freeze in every logically possible way. This is simply because there may be logically possible ways that are physically impossible. The formation of the ice is limited by the fundamental nature of water. Chance is responsible for the actual formation, but the nature of water limits the range of potential chance formations. Similarly, while chance determines the actual values of the symmetry break, the ontic field limits the range of potential values and sets the probability distribution of those potential values.

Although there are significant details yet to be clarified, it is consistent with the observed data, the conservation laws, and quantum theory that the existence of this *material* universe is the result of a vacuum fluctuation of the quantum field, and further that the existence of the *finely-tuned nature* of this universe may be explained as the result of a symmetry break grounded in the ontic field.

#### *11.4.3 Considering the ontic field explanation as a single universe explanation*

Let us assume that scientists are successful in specifying the ontic field such that this material universe can be explained as a vacuum fluctuation and the fine-tuned nature of the universe can be explained as the outcome of a symmetry breaking process. Usually this approach incorporates other universes, but let me see if I can dispense with these

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<sup>202</sup> This is the specification of the 'meta-theory' to which Davies refers (Davies 1993) 205.

<sup>203</sup> This would be the same as the die having any logically possible number showing on the uppermost face when it lands. To make this conceivable, just think of a die with no numbers on the faces, but when it lands, any logically possible number appears on the uppermost face.

other universes. I approach this task in two ways. Firstly, I assume that other fluctuations and symmetry breaks exist, but I argue that these other fluctuations and symmetry breaks may not be considered as other universes. Secondly, I consider the possibility that these other fluctuations and symmetry breaks do not exist. This second approach is based on the idea that once we have specified the process that generates vacuum fluctuations and symmetry breaks, then the number of other fluctuations and symmetry breaks is irrelevant to the explanation of this universe. This second approach is consistent with the avoidance of the inverse gambler's fallacy. Once we understand the roll of a die, we need not postulate, *indeed we should not postulate*, many other rolls to explain why one roll occurred. All we need, to understand the existence of our universe, is the existence of a process that produced this universe, and the ontic field gives us this.

So, first consider the possibility that there are other fluctuations of the vacuum that generate 'universes' other than our own. What would these universes be like? We can answer that question by returning to Tryon's original description of quantum vacuum fluctuation.

...quantum electrodynamics reveals that an electron, positron and photon occasionally emerge spontaneously from a perfect vacuum. When this happens, the three particles exist for a brief time, and then annihilate each other, leaving no trace behind (Tryon 1990) 218.

If we assume that other possible fluctuations are equivalent to these quantum fluctuations described by Tryon, then they would create 'universes' that exist for a brief time and comprised only a few elementary particles. If these other fluctuations actually exist, then based on the nature of their temporal and spatial extension, we may not want to call them other universes. If they existed only for a brief time or existed only across a small space, then we may regard them simply as other 'bits and pieces' rather than other universes. I can take a similar position with respect to the results of different symmetry breaks. Depending on the nature of the break, the outcomes may not be recognisable as universes.

The second approach suggests that the existence of other vacuum fluctuations and symmetry breaks are not necessary to explain this fluctuation, or this symmetry break.

Recall that other rolls of a die do not help explain why a particular roll, a 3 (say), occurs. Similarly, other fluctuations and symmetry breaks do not help explain this fluctuation or this symmetry break. So the existence or non-existence of other fluctuations and symmetry breaks does not effect the explanation of this fluctuation or this symmetry break. Let us examine the sense in which this universe can be explained by a single fluctuation and/or symmetry break.

#### *11.4.4 Does the ontic field explanation raise the probability the fine-tuning?*

Scientific explanations do not necessarily make events probable but the *orthodox* position is that they should raise the probability of the events they explain. So the probability of the explanandum must be greater, given the explanans, than in its absence. The explanans is the ontic field, and the explanandum is the existence of this fine-tuned universe. So does the ontic field raise the probability of the existence of this fine-tuned universe? The ontic field necessarily gives a positive probability of this fine-tuned universe existing. What this probability might be is not central to this analysis. The central issue is whether the probability of the existence of this fine-tuned universe given the ontic field is greater than the probability in its absence. This is a difficult thing to quantify, because it is not obvious what reality would be like in the absence of the ontic field. But let me use the standard approach and compare the probability of this universe given the ontic field with the probability given chance operating in logical probability space. It seems reasonable that the probability would be greater given the ontic field, because the ontic field (I assume) does not allow for the existence of all logical possibilities. The explanation raises the probability of this universe, and so *on the orthodox position*, the ontic field explains the existence of this universe.<sup>204</sup>

#### *11.4.5 The ontic field explanation and the conformity maxim*

As an alternative to the orthodox position, we can think of the ontic field, not as *raising* the probability of this universe, but simply *giving* this universe its probability. Thus

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<sup>204</sup> This argument developed from a comment made by Phil Dowe (pers. comm.).

another way of determining whether this is a good explanation is to use the conformity maxim. Here we do not consider whether the explanation raises the probability of the event it explains, but rather, we consider the probabilistic conformity between the explanation and the event explained. We determine whether the *empirical frequency distribution* within which the event is located, matches the *hypothetical frequency distribution* generated by the explanation. In the case of the universe, and given that we have access to only one universe, if the hypothetical frequency distribution generated by the explanation is consistent with the existence of this universe, then this universe conforms to the explanation. This does not tell us much because all explanations that give this universe a non-zero probability of existence conform to its existence. But this limitation is because we must consider the universe as an isolated system. If the universe were not isolated (or at least if we had access to other universes) we could consider the empirical frequency distribution of universes and separate the explanations that generate hypothetical frequency distributions matching the empirical one from those that do not.<sup>205</sup>

The general form of the ontic field explanation is the same as that of atomic decay. We can explain the general principle of atomic decay. But we cannot explain why a particular atom decays at a particular time. With respect to a time indexed atomic decay, all we can do is confirm that the decay is consistent with the general process. The ontic field explanation of this universe is similar. We can explain the general process of universe creation. But we cannot explain why this universe has the finely-tuned values that it does. With respect to this finely-tuned universe, all we can do is confirm that the existence of the universe is consistent with the general process of universe creation. The ontic field explanation can be understood in terms of the D-N-P form of scientific explanation developed by Railton (Railton 1978). We can explain the existence of this universe by deducing its probability from ontic field theory and adding the 'parenthetic

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<sup>205</sup> Notice how this reinforces Aristotle's position that we cannot have scientific knowledge of individuals, only of types, species or sorts.

addendum' stating that the universe did in fact emerge.<sup>206</sup> This explanation does not distinguish between the 'fact' of this universe and the 'foil' of some other ontically possible universe. But this is the case for all indeterministic events. Atomic theory does not explain why an atom decays at  $t^1$  as opposed to at  $t^2$ .

*11.4.6 The ontic field explanation does not imply other universes*

This is not a multiverse explanation. If we can suitably specify the process of symmetry breaking, then we do not need to postulate other universes. Indeed, if we postulate other universes, then we commit the inverse gambler's fallacy (Hacking 1987). All we need do is specify the process by which this universe can be generated and we have an explanation. We do not need this process to have produced many other universes. The strength of this explanation is not affected by whether or not the process has also generated other universes. Many other universes are not the explanation of this universe. The explanation of this universe relates to the process that generated it. Just as the process associated with the roll of a pair of dice is the explanation for the roll of W3B5, and the existence or non-existence of many other rolls does not affect this explanation.

One might argue that once a process is specified that can generate one universe, then this *implies* the existence of other universes, but this is speculation and not related to the explanation of this universe. To explain the pattern of ice on a pond, we need to ask questions about the nature of water, not questions about whether the pond froze more than once. On the other hand, one might argue that once we have a process that can create one universe, it does not require significantly more metaphysical resources to postulate many universes. By analogy, if a pond has frozen once, it may have frozen many times. But again, this requires commitments that we simply do not need to make to explain the fine-tuning of this universe. I am not concerned with explaining other universes that may or may not exist. I am interested in explaining the fine-tuning of *this* universe.

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<sup>206</sup> If the probability deduced from quantum field theory is 1, then we do not need to use the D-N-P model, we can use the standard D-N model of scientific explanation.

#### *11.4.7 The next step?*

Some might claim that this is no better than 'explaining' this universe by noting that it is one of the logically possible universes, and that it exists by chance. But this is not accurate, because we can now begin determining the structure of the ontic possibility space of universes. We can start with what is possible in the possibility space of the quantum field, and I hold that this is more restricted than logical possibility. We can build out from there to an understanding of ontic possibility. This is the beginnings of our understanding of the nature of ontic possibility space. This understanding may involve ideas drawn from chaos and quantum theory. Admittedly, we have not explained the existence of the ontic field, but this is no worse than leaving God unexplained, and it may be significantly better. To say that we have left the ontic field unexplained, at least means that we *know* what the next task is; namely the explication of the ontic field. This is the task of understanding Davies's 'meta-theory' and Mellor's 'immaterial chance set-up'. Our task is well-defined, and understanding the ontic field seems more manageable than understanding the mind of God.

#### **11.5 In conclusion**

Let me review my thesis. It is a comprehensive analysis of the fine-tuning of the universe, but it also touches on broader issues in the philosophy of science. A central theme is the impact of indeterminism on our ability to understand and explain the world, and this is closely related to another important theme: the relationship between reality (the ontic) and our conception of reality (the epistemic). I structured the analysis in two parts. The first part was concerned with the characterisation of the probability of the fine-tuning. The second was concerned with the appropriate response to that probabilistic characterisation.

I began with an analysis of the cosmological theories that motivate the fine-tuning debate. This analysis focused on the basic fine-tuning conditional: *If the laws and/or initial conditions of the universe had been slightly different then carbon-based life would not be possible*. I argued that it is necessary to take a realist interpretation of the cosmological theories in order for the debate to be well founded. If an anti-realist

interpretation is taken of the antecedent, then the conditional is false. I then considered the modality of the debate. For the debate to be meaningful, I argued, the other possible universes must be ontically possible, rather than merely epistemically possible. I then considered the nature of ontic possibility space. I argued that, given chaotic and quantised systems exist in the physical world, it is reasonable to consider that the physical world itself may have been generated by a chaotic or quantised ontic system. I argued that if the ontic possibility space was chaotic or quantised then slightly different universes may well not be life allowing, and this would explain the fine-tuning conditional.

I then moved on to an analysis of the probability of the fine-tuning. I examined the tension between ontic probability and the probability calculus. Ontic (and physical) probability does not conform to the calculus. However probability is widely used in much of physics, so I contend that the idea of ontic (and physical) probability needs to be taken seriously. I then considered the issue of partitioning the probability space. I contrasted demonstrative partitioning with non-demonstrative partitioning and argued that non-demonstrative partitioning is fundamentally objective while demonstrative partition is fundamentally subjective. I argued that (in an equi-probable space) a demonstrative partition is required in order to generate improbability. Otherwise any event is simply as probable or as improbable as any other event: all events are iso-probable. In order to generate a reasonable sense of improbability in an equi-probable space, I argued that a demonstrative partition is needed. However our use of such a partition in the fine-tuning debate needs a justification, and I argued that there is no obvious objective justification. This leaves only the non-demonstrative partition and iso-probability. Thus, I concluded that in the case of the fine-tuning, in the absence of a justification for the demonstrative partition (and assuming an equi-probability space), the fine-tuning is not improbable but iso-probable.

The second part of the thesis embraces the reality of indeterminism. One of the current theories describing the origin of the universe suggests that the fine-tuning may have been set indeterministically by a 'symmetry breaking' mechanism. If this is the case, it has profound implications for how we explain the origin of the universe. I analysed how

indeterminism impacts on our explanatory strategies. In particular, I considered the explanatory assumption that explanation are in some sense 'good' because they raise the probability of the events they explain. I argued that, in the case of the universe (considered as an isolated indeterministic event), this explanatory strategy is misguided. I argued that it is not reasonable to choose between hypotheses based on the probability of the isolated indeterministic events they explain. In an indeterministic world an isolated event may be probable or improbable, but based only on the evidence of the event itself: there is no way to determine the ontic probability of the event. Thus there is no way to decide between the competing hypotheses. I argued that if we make the assumption that the event was probable, and then use this assumption to confirm the hypothesis that made the event probable, we are engaged in circular reasoning. I concluded that we simply cannot choose between competing hypotheses with respect to an isolated indeterministic event.

The analysis then turned to the process that triggers the need to seek an explanation for the fine-tuning. I analysed the role of surprise, specification and analogies in the debate, with specific reference to the conclusions I had drawn earlier in the thesis with respect to probability and circularity. I argued that the fine-tuning should be considered neither surprising nor a specified event. I demonstrated that the analogies used in the fine-tuning literature to prompt explanation were not analogous to the fine-tuning, and thus did not indicate that the fine-tuning required explanation. I then considered the weaknesses of current explanations for the fine-tuning, multiple universes and design. I argued that the existence of many universes would satisfactorily explain the fine-tuning; however, I noted that the fine-tuning gives no reason to believe in multiple universes. With reference to the design explanation, I argued that God would be required to act through indeterministic laws to ensure the certain existence of intelligent organisms, however this process would be empirically indistinguishable from the normal functioning of indeterministic laws. Thus this explanation is subject to metaphysical scepticism. Finally, I suggested a third explanation, in which this fine-tuned universe is the isolated outcome of an indeterministic quantum process, and I argued that, given our evidence, this would be the most appropriate response to the fine-tuning.

## 12 References

- Aristotle. 1975. *Posterior Analytics*. Translated by J. Barnes. Oxford: Clarendon Press.
- — —. 1989. *Prior Analytics*. Translated by R. Smith. Indianapolis: Hackett Publishing Company.
- Armstrong, David M. 1989. *What is a Law of Nature?* Cambridge: Cambridge University Press.
- Barrow, John D., and Frank J. Tipler. 1988. *The Anthropic Cosmological Principle*. Oxford: Oxford University Press.
- Bostrom, Nick. 2002. *Anthropic Bias: Observation Selection Effects in Science and Philosophy*. London: Routledge.
- — —. 2002. Self-Locating Belief in Big Worlds: Cosmology's Missing Link to Observation. *The Journal of Philosophy*:607-623.
- Brown, James Robert. 2000. Mathematics, Role in Science. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell Publishers.
- Carlson, Erik, and Erik J. Olsson. 1998. Is our existence in need of further explanation? *Inquiry-an Interdisciplinary Journal of Philosophy* 41 (3):255-275.
- Carnap, Rudolf. 1950. *Logical Foundations of Probability*. Chicago: University of Chicago Press.
- Carter, Brandon. 1974. Large Number Coincidences and the Anthropic Principle. In *Confrontation of Cosmological Theories with Observational Data*, edited by M. S. Longair. Boston: D. Reidel.
- Cleland, Carol E., and Christopher F. Chyba. forthcoming. Does 'life' have a definition? In *Planets and Life: The Emerging Science of Astrobiology*, edited by Sullivan and Baross.
- Clifton, Robert. 1991. Critical Notice, Universes. *Philosophical Quarterly* 41:339-44.
- Collins, C. B., and S. W. Hawking. 1973. Why is the Universe Isotropic? *The Astrophysical Journal* 180:317-334.
- Collins, Robin. 2003. Evidence for Fine-Tuning. In *God and Design*, edited by N. A. Manson. London: Routledge.
- Colyvan, Mark, Jay Garfield, and Graham Priest. forthcoming. Problems with the Argument from Fine Tuning. *Synthese*.

## References

- Craver, Carl F. 2002. Structures of Scientific Theories. In *The Blackwell Guide to the Philosophy of Science*, edited by P. Machamer and M. Silberstein. Oxford: Blackwell.
- Curtis, Helena. 1983. *Biology*. New York: Worth Publishers.
- Davies, Paul. 1993. *The Mind of God*. London: Penguin Books.
- . 2003. The appearance of design in physics and cosmology. In *God and Design*, edited by N. A. Manson. London: Routledge.
- . 2004. Multiverse cosmological models. *Modern Physics Letters A* 19 (10):727-743.
- Dawkins, Richard. 1991. *The Blind Watchmaker*. London: Penguin.
- Dembski, William A. 1998. *The Design Inference: Eliminating Chance Through Small Probabilities*. Edited by B. Skyrms, *Cambridge Studies in Probability, Induction and Decision Theory*. Cambridge: Cambridge University Press.
- . 1999. *Intelligent Design; The bridge between science and theology*. Downers Grove, Illinois: InterVarsity Press.
- Dowe, Phil. The Inverse Gambler's Fallacy Revisited: Multiple Universe Explanations of Fine Tuning.
- . 1997. Chance and Providence. *Science and Christian Belief* 9 (1):3-20.
- . 1999. Response to Holder: Multiple Universe Explanations are not Explanations. *Science and Christian Belief* 11:67-68.
- Eagle, Antony. 2004. Twenty-one arguments against propensity analyses of probability. *Erkenntnis* 60:371-416.
- Earman, John. 1987. The SAP also Rises: A Critical Examination of the Anthropic Principle. *American Philosophical Quarterly* 24 (4):307-317.
- Everett, Hugh. 1973. 'Relative State' Formulation of Quantum Mechanics. In *The Many Worlds Interpretation of Quantum Mechanics*, edited by B. S. DeWitt and N. Graham. Princeton: Princeton University Press.
- Feldman, Fred. 1995. *life*. In *A Companion to Metaphysics*, edited by J. Kim and E. Sosa. Oxford: Blackwell.
- Fetzer, James H. 1970. Dispositional Probabilities. Paper read at Boston Studies in the Philosophy of Science Volume VIII PSA 1970.
- Field, Hartry H. 1980. *Science Without Numbers - A Defence of Nominalism*. Princeton, NJ: Princeton University Press.

## References

- Fisher, R.A. 1959. *Statistical Methods and Statistical Inference*. London: Oliver & Boyd.
- Fitelson, Branden, Christopher Stephens, and Elliott Sober. 1999. How Not to Detect Design - Critical Notice: William A. Dembski, "The Design Inference". *Philosophy of Science* 66 (3):472-488.
- Fulmer, Gilbert. 2001. A fatal logical flaw in Anthropic Principle Design Arguments (Teleological polemic for divine existence). *International Journal for Philosophy of Religion* 49 (2):101-110.
- Fumerton, Richard. 1992. inference to the best explanation. In *A Companion to Epistemology*, edited by J. Dancy and E. Sosa. Oxford: Blackwell Publishers.
- Giere, Ronald N. 2000. Theories. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell Publishers.
- Gillies, Donald. 2000. Varieties of Propensity. *British Journal for the Philosophy of Science* 51:807-835.
- Gleick, James. 1988. *Chaos; Making a New Science*. London: Sphere Books.
- Gott, J. Richard. 1982. Creation of Open Universes from de Sitter Space. *Nature* 295:304-7.
- Gould, Stephen Jay. 1987. *The Flamingo's Smile*. London: Penguin.
- Gribbin, John, and Martin J. Rees. 1991. *Cosmic Coincidences*. London: Black Swan.
- Hacking, Ian. 1987. The Inverse Gambler's Fallacy: the Argument from Design. The Anthropic Principle Applied to Wheeler Universes. *Mind* 96:331-340.
- Hájek, Alan. 2001. Probability, Logic, and Probability Logic. In *The Blackwell Guide to Philosophical Logic*, edited by L. Goble. Oxford: Blackwell.
- — —. 2003. Conditional Probability Is the Very Guide of Life. In *Probability Is the Very Guide of Life*, edited by H. Kyburg, Jr. and M. Thalos. Chicago: Open Court.
- — —. 2003. *Interpretations of Probability* (Summer 2003). Stanford Encyclopedia of Philosophy, 07/05/03 2003 [cited 25/07/03 2003]. Available from <http://plato.stanford.edu/archives/sum2003/entries/probability-interpret/>.
- Hájek, Alan, and Ned Hall. 2002. Induction and Probability. In *The Blackwell Guide to the Philosophy of Science*, edited by P. Machamer and M. Silberstein. Oxford: Blackwell Publishers.
- Hardie, Ronald G. 1990. *Collins Gem English Grammar*. Glasgow: HarperCollins Publishers.

## References

- Harré, Rom. 2000. *Laws of Nature*. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell Publishers.
- Hawking, Stephen W. 1989. *A Brief History of Time*. London: Bantam Books.
- Healey, Richard. 2001. Quantum Mechanics. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. London: Blackwell.
- Heidegger, Martin. 1962. *Being and Time*. Translated by J. Macquarrie and E. Robinson. New York: HarperCollins.
- Hempel, Carl G. 1965. *Aspects of Scientific Explanation*. New York: Free Press.
- Hesse, Mary. 2000. Models and Analogies. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell Publishers.
- Hitchcock, Christopher R., and Wesley C. Salmon. 2001. Statistical Explanation. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell.
- Holder, Rodney. 2001. The realization of infinitely many universes in cosmology. *Religious Studies* 37:343-350.
- — —. 2002. Fine-Tuning, Multiple Universes and Theism. *Nous* 36 (2):295-312.
- Horwich, Paul. 1982. *Probability and Evidence*. Edited by D. H. Mellor, *Cambridge Studies in Philosophy*. Cambridge: Cambridge University Press.
- Howson, Colin. 2001. Evidence and Confirmation. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell.
- Hughes, R. I. G. 1989. Bell's Theorem, ideology, and structural explanation. In *Philosophical Consequences of Quantum Theory: Reflections on Bell's Theorem*, edited by J. T. Cushing and E. McMullin. Notre Dame, IN: University of Notre Dame Press.
- Hume, David. 1969. *Dialogues Concerning Natural Religion*. New York: Hafner Publishing Company. Original edition, 1779.
- — —. 1984. *A Treatise of Human Nature*. London: Penguin Books. Original edition, 1739.
- Humphreys, P. 1985. Why Propensities Cannot be Probabilities. *Philosophical Review* 94:557-570.
- Husserl, Edmund. 1970. *Logical Investigations*. Translated by J. N. Findlay. London: Routledge and Kegan Paul. Original edition, 1913-21.
- Jeffrey, Richard C. 1969. Statistical explanation vs. statistical inference. In *Essays in*

## References

- Honour of Carl G. Hempel*, edited by N. Rescher. Dordrecht: D. Reidel.
- Kitcher, Philip. 1993. *The Advancement of Science*. New York: Oxford University Press.
- Kolmogorov, A. N. 1950. *Foundations of Probability*. New York: Chelsea Publishing Company. Original edition, (1933) *Grundbegriffe der Wahrscheinlichkeitrechnung*. *Ergebnisse Der Mathematik*.
- Kyburg, Henry, Jr. 1970. *Probability and Inductive Logic*. London: The Macmillan Company.
- Laplace, Pierre. 1825. *Essai philosophique sur les probabilités*. 5 ed. Paris: Bachelier.
- Leplin, Jarrett. Realism and Instrumentalism. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell Publishers.
- Leslie, John. 1989. *Universes*. London: Routledge.
- — —. 1995. finite/infinite. In *A Companion to Metaphysics*, edited by J. Kim and E. Sosa. Oxford: Blackwell Publishers.
- — —. 2003. The Meaning of Design. In *God and Design*, edited by N. A. Manson. London: Routledge.
- — —, ed. 1990. *Physical Cosmology and Philosophy*. Edited by P. Edwards, *Philosophical Topics*. New York: Macmillan Publishing Company.
- Lewis, David. 1973. *Counterfactuals*. Cambridge: Harvard University Press.
- — —. 1986. A Subjectivist's Guide to Objective Chance. In *Philosophical Papers: Volume II*. New York: Oxford University Press.
- Linde, Andrei. 1983. *Modern Physics Letters A* A1:81.
- Lipton, Peter. 2000. Inference to the Best Explanation. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell Publishers.
- Loewer, Barry. 1995. law of nature. In *A Companion to Metaphysics*, edited by J. Kim and E. Sosa. Oxford: Blackwell Publishers.
- — —. 2001. Determinism and Chance. *Studies in the History and Philosophy of Modern Physics* 32 (4):609-620.
- Loux, Michael J. 1979. *The Possible and the Actual: Readings in the Metaphysics of Modality*. Ithaca: Cornell University Press.
- Lycan, William G. 2002. The Metaphysics of Possibilia. In *The Blackwell Guide to Metaphysics*, edited by R. M. Gale. Oxford: Blackwell.

## References

- Mackie, J.L. 1969. The Relevance Criterion of Confirmation. *British Journal for the Philosophy of Science* 20:27-40.
- Manson, Neil A. 2000. There Is No Adequate Definition of 'Fine-tuned for Life'. *Inquiry* 43:341-52.
- , ed. 2003. *God and Design: The Teleological Argument and Modern Science*. London: Routledge.
- Manson, Neil A., and Michael J. Thrush. 2003. Fine-Tuning, Multiple Universes, and the "This Universe" Objection. *Pacific Philosophical Quarterly* 84:67-83.
- McGrew, Timothy, Lydia McGrew, and Eric Vestrup. 2001. Probabilities and the Fine Tuning Argument: a Sceptical View. *Mind* 110 (440):1027-1037.
- Mellor, D. H. 1973. God and Probability. In *God, Man and Religion*, edited by K. E. Yandell. New York: McGraw-Hill.
- . 1995. *The Facts of Causation*. Edited by T. Crane and J. Wolff, *International Library of Philosophy*. London: Routledge.
- . 2003. Too Many Universes. In *God and Design*, edited by N. A. Manson. London: Routledge.
- Mermin, N. David. 1985. Is the moon there when nobody looks? Reality and the quantum theory. *Physics Today*:38-47.
- Miller, Kenneth R. 1999. *Finding Darwin's God*. New York: HarperCollins.
- Mortensen, Chris. 1998. On the Possibility of Science Without Numbers. *Australasian Journal of Philosophy* 76 (2):182-197.
- Morton, Adam. 2003. *A Guide Through The Theory of Knowledge*. 3rd ed. Oxford: Blackwell.
- Percival, Philip. 2000. Probability. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell Publishers.
- Peterson, Micheal, William Hasker, Bruce Reichenbach, and David Basinger. 1991. *Reason And Religious Belief: An Introduction to the Philosophy of Religion*. New York: Oxford.
- Pirani, Felix. 1999. *Introducing the Universe*. Cambridge: Icon Books.
- Popper, K., and J. Eccles. 1977. *The Self and Its Brain*. New York: Springer International.
- Price, Huw. 1996. *Time's Arrow and Archimedes' Point*. Oxford: Oxford University Press.

## References

- Pruss, Alexander R. 2002. The Actual and the Possible. In *The Blackwell Guide to Metaphysics*, edited by R. M. Gale. Oxford: Blackwell.
- Railton, Peter. 1978. A deductive-nomological model of probabilistic explanation. *Philosophy of Science* 45:206-26.
- Ramsey, Frank P. 1990. *Philosophical Papers*. Cambridge: Cambridge University Press.
- Rees, Martin J. 2003. Other Universes: A scientific perspective. In *God and Design*, edited by N. A. Manson. London: Routledge.
- Reichenbach, Hans. 1949. *The Theory of Probability*. Berkeley: University of California Press.
- Resnik, Michael D. 1987. *Choices - An Introduction to Decision Theory*. Minneapolis: University of Minnesota Press.
- Roeper, P., and H. Leblanc. 1999. *Probability Theory and Probability Logic*. Toronto: University of Toronto Press.
- Russell, Bertrand. 1967. *Why I am not a Christian*. London: Allen & Unwin.
- Salmon, Merrilee H., John Earman, Clark Glymour, James G. Lennox, Peter Machamer, J. E. McGuire, John D. Norton, Wesley C. Salmon, and Kenneth Schaffner, F. 1992. *Introduction to the Philosophy of Science*. Englewood Cliffs, New Jersey: Prentice Hall.
- Salmon, Wesley C. 1990. *Four Decades of Scientific Explanation*. Minneapolis: University of Minnesota Press.
- — —. 1992. explanation. In *A Companion to Epistemology*, edited by J. Dancy and E. Sosa. Oxford: Blackwell Publishers.
- Scriven, Michael. 1966. *Primary Philosophy*. New York: McGraw-Hill.
- Sklar, Lawrence. 1995. *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*. Cambridge: Cambridge University Press.
- Smith, Barry. 2000. ontology. In *A Companion to Metaphysics*, edited by J. Kim and E. Sosa. Oxford: Blackwell Publishers.
- Smith, Quentin. 1986. World Ensemble Explanations. *Pacific Philosophical Quarterly* 67:73-86.
- — —. 1997. The Ontological Interpretation of the Wave Function of the Universe. *The Monist* 80 (1):160-185.
- Smolin, Lee. 1997. *The Life of the Cosmos*. Oxford: Oxford University Press.

## References

- Sober, Elliott. 2003. The Design Argument. In *God and Design*, edited by N. A. Manson. London: Routledge.
- Stalnaker, Robert. 1995. modalities and possible worlds. In *A Companion to Metaphysics*, edited by J. Kim and E. Sosa. Oxford: Blackwell Publishers.
- Sterelny, Kim, and Paul Griffiths. 1999. *Sex and Death: An Introduction to Philosophy of Biology*. Edited by D. L. Hull, *Science and its Conceptual Foundations*. Chicago: The University of Chicago Press.
- Suppe, Frederick. 2000. Axiomatization. In *A Companion to the Philosophy of Science*, edited by W. H. Newton-Smith. Oxford: Blackwell Publishers.
- Swinburne, Richard. 1973. *An Introduction to Confirmation Theory*. London: Methuen.
- — —. 1990. Argument from the Fine-Tuning of the Universe. In *Physical Cosmology and Philosophy*, edited by J. Leslie. New York: Macmillan Publishing Company.
- — —. 1991. *The Existence of God*. Oxford: Clarendon Press.
- — —. 2003. The argument to God from fine-tuning reassessed. In *God and Design: The teleological argument and modern science*, edited by N. A. Manson. London: Routledge.
- — —. 2004. *The Existence of God*. 2nd ed. Oxford: Oxford University Press.
- Tegmark, Max. 2003. Parallel Universes. *Scientific American* 288 (5):30-41.
- Tryon, Edward, P. 1990. Is the Universe a Vacuum Fluctuation? In *Physical Cosmology and Philosophy*, edited by J. Leslie. New York: Macmillan.
- Uvarov, E. B. , D. R. Chapman, and Alan Isaacs. 1982. *The Penguin Dictionary of Science*. London: Penguin Books.
- van Fraassen, Bas C. 1980. *The Scientific Image*. Edited by L. J. Cohen, *Clarendon Library of Logic and Philosophy*. Oxford: Clarendon Press.
- van Inwagen, Peter. 2002. *Metaphysics*. Edited by N. Daniels and K. Lehrer, *Dimensions of Philosophy Series*. Boulder: Westview Press.
- Vilenkin, Alex. 1983. *Phys. Rev.* D27:2848.
- Warren, N. G. 1983. *Physics Outlines*. Sydney: Pergamon Press.
- Wheeler, John Archibald. 1990. Beyond the End of Time. In *Physical Cosmology and Philosophy*, edited by J. Leslie. New York: Macmillan Publishing Company.
- White, Roger. 2000. Fine-tuning and multiple universes. *Nous* 34 (2):260-276.

### *References*

- Wittgenstein, Ludwig. 1953. *Philosophical Investigations*. Translated by G. E. M. Anscombe. Oxford: Blackwell.
- Wood, Graham. 2002. A Review of Swinburne's "Argument from the Fine-Tuning of the Universe".
- — —. 2003. Dembski's Trojan Horse; Specification and the Fine-Tuning of the Universe.