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The Fine-Tuning of Nomic Behavior in Multiverse Scenarios

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Abstract

The multiverse hypothesis (the view that there is not just one world or universe in existence, bur rather that there are many) is the leading alternative to the competing fine-tuning hypothesis (the laws of physics and constants are fine-tuned for the existence of life). The multiverse dispels many aspects of the fine-tuning argument by suggesting that there are different initial conditions in each universe, varying constants of physics, and the laws of nature lose their known arbitrary values; thus, making the previous single-universe argument from fine-tuning incredibly weak. The position that will be advocated will be that a form of multiverse could exist and that any level of Tegmark's multiverse does not circumvent the fine-tuning argument for the existence of a fine-tuner (a mind). An argument will be presented suggesting that the multiverse could strengthen the fine-tuning argument by narrowing down the parameters of the data to a more fundamental description needed for the multiverse to function as it does since it may be the case that some physical descriptions are not the same in every universe. That is, the task of explaining how the multiverse mechanism functions cannot be accounted for by the multiverse itself. Fine-tuning by a mind serves as a sufficient and best explanation for the data.

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CHAPTER ONE: INTRODUCTION

I. Preliminary Comments

The task of this thesis will be to demonstrate that there is fine-tuning of nomic behavior for the existence of human life in the universe and, if a multiverse exists, that there is fine-tuning behind the multiverse. The fundamental constants of nature, laws of physics, and the mechanisms needed for bubble universe inflation will serve as evidence for the hypothesis that there is a fine-tuner. It is not the task of this thesis to answer the teleological question with a descriptive answer to *what* the purpose of life is; rather, the task at hand will be to argue *that* there is a purpose, which is detectable via purposive fine-tuning.

There is no doubt among cosmologists and philosophers that the universe we inhabit is fine-tuned*, per se*. If the value of physical laws were any different then this universe could not produce observers. Fine-tuning is a metaphysically and religiously neutral term used to simply state that if the universe had been otherwise it would not harbor human life. The question is whether this fine-tuning is the result of a fine-tuner or whether it is just a semantic tool to describe the balanced values that is explained by competing non-fine-tuning hypotheses. The term *design* does, however, carry metaphysical and religious implication. In recent decades these metaphysical and religious implications have been under criticism and rejected by many as an acceptable explanatory hypothesis for the cosmological data. It is my contention that the fine-tuning of nomic behavior in multiverse scenarios is the consequence of an antecedent mind—a fine-tuner. The more information—the values of laws and constants—the more demand for an *explanans*. The more universes there are the more information there is. A mind is the only known *explanans* for the origin of information (and not merely the change of information).

II. Defining Terms and Abbreviations

1. **Universe**. Whenever I refer to this term I refer to it as a single sub-system composed of its own initial conditions, constants, laws of nature, etc., which are causally distinct from other sub-systems. An example of this would be referential to what we understand to be our observable region/system (the Hubble volume, almost 100 billion light years in diameter, or a Friedmann-Robertson-Walker [FRW] system). This would also include any system that is very small and may have or will collapse.[1] The aggregate of these sub-systems would compose a multiverse.
2. **Multiverse**. This will refer to the landscape of all space and time and may consist of many universes or a set of universes. The semantic domain for *multiverse* encompasses four different descriptions of reality. For definitions of the different types of multiverses please see chapter four sections II-IV.
    a. **Level One Multiverse (L1M).**
    b. **Level Two Multiverse (L2M).**
    c. **Level Three Multiverse (L3M).**
    d. **Level Four Multiverse (L4M).**
3. **Observer**. An observer is any intelligent agent that has the ability to live and function in the given system in which it inhabits. By intelligence I mean the ability to rationalize, think, and be self-aware. This does not include mere *life* since all life is not intelligent life, i.e. bacterium does not meet the sufficient conditions for intelligent life nor do rabbits because they do not meet the criteria for intelligence. This is similar, if not identical, to human beings (*homo sapiens sapiens*).

[1] Unless otherwise noted, *universe* will not include other branches of the wavefunction in unitary

4. **Constants**. Physical constants are the values of certain spacetime, energy, and natural laws that have a set parameter that determine the structure and function of a life-permitting universe. Constants will vary in value from universe to universe in multiverse scenarios. When I refer to 'constants' here I mean what we presently observe as being constant. For example, the value of gravity may vary from universe to universe. No matter which universe is indexed the value of gravity will always be determined by a mind referred to in the fine-tuner hypothesis. The following are this universe's constants and their values.[2]

   a. **Constants of Space and Time.**

      1. Planck length (the minimum interval of space), $l_p = 1.62 \times 10^{-33}$ cm.
      2. Planck time (the minimum interval of time), $t_p = 5.39 \times 10^{-44}$ sec.
      3. Planck's constant (this determines the minimum unit of energy emission), $h = 6.6 \times 10^{-34}$ joule seconds.
      4. Velocity of light, $c = 300{,}000$ km/sec.

   b. **Energy Constants.**

      5. Gravitational attraction constant, $G = 6.67 \times 10^{-11}$ Nm^2/kg^2.
      6. Weak force coupling constant, $g_w = 1.43 \times 10^{-62}$.
      7. Strong nuclear force coupling constant, $g_s = 15$.

   c. **Individuating Constants (Composition of the Electromagnetic Force).**

      8. Rest mass of a proton, $m_p = 1.67 \times 10^{-27}$ kg.
      9. Rest mass of an electron, $m_e = 9.11 \times 10^{-31}$ kg.
      10. The electron or proton unit charge, $e = 1.6 \times 10^{-19}$ coulombs.

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[2] As found in Robert J. Spitzer's *New Proofs for the Existence of God: Contributions of Contemporary Physics and Philosophy* (Grand Rapids, MI: Eerdmans, 2010), 52-56.

11. Minimum mass in our universe, (hc/G)½ = 2.18 x 10^{-8} kg.

d. **Large-Scale and Fine Structure Constants.**

12. Rest mass (the current observable mass of the universe) = 10^{53} kg.
13. Boltzmann's constant, k = 1.38 x 10^{-23} J/°K
14. Hubble constant, H = 2 x 10^{-18} (SI units—le système international d'unités [metric units]).
15. Cosmological constant, $\Lambda < 10^{-53}$ (SI units).
16. Cosmic photon/proton ratio, $S = 10^{9}$ (SI units).
17. Permittivity of free space, ε = 8.85 x 10^{-12} (SI units).
18. Electromagnetic fine structure constant, α = 7.30 x 10^{-3} (SI units).
19. Weak fine structure constant, α_w = 3.05 x 10^{-12} (SI units).
20. Gravitational fine structure constant α_G = 5.90 x 10^{-39} (SI units).

5. **Fine-Tuner Hypothesis (FT).** The hypothesis that the values of physical constants and laws are the consequence of an antecedent mind that causally determined the values. This mind must be antecedent to any universe or multiverse. This only requires that there be one mind to determine the values. One mind is sufficient for the origin of information and the set values of each universe or multiverse. Many minds are not inconsistent with this hypothesis but it does not require many minds since they will become superfluous. It may be the case that there are many minds that can or have determined the values but the quantity of minds is irrelevant. It is important to remember that this hypothesis does not and cannot argue for God.[3]

[3] When I refer to 'God' here I refer to the classic understanding of God being the greatest conceivable being. FT cannot make and postulations about this mind's power, goodness, aseity, special revelation, etc. This argument may be used in a cumulative case argument for the existence of God but is not sufficient in itself for the conclusion of FT to be God.

6. **Non-Fine-Tuner Hypothesis (~FT).** Any explanatory hypothesis for the origin of information and the values of physical constants and laws contrary to FT.
7. **Life-Permitting Universe (LPU)**. This will refer to the spatiotemporal universe system in which observers can exist.
8. **Life-Permitting Multiverse (LPM).** This will refer to any level of the multiverse that functions in an anthropically friendly manner resulting in the production of LPUs.
9. **Metaphysical Multiverse (MM)**.
10. **Necessitarianism (NT)**.
11. **Regularity Theory (RT)**.

III. The Problem for Fine-Tuning in the Milieu of the Multiverse

The multiverse hypothesis is the leading alternative to the competing hypothesis that the observed fine-tuning is the result of a fine-tuner (FT). The multiverse dispels many aspects of the fine-tuning argument by suggesting that there are different initial conditions in each universe, varying constants of physics, and the laws of nature lose their known arbitrary values; thus, making the previous single-universe FT argument incredibly weak.

There are four options for why design is either unnecessary to invoke or illusory if the multiverse hypothesis is used as an alternative *explanans*. Design might be (1) illusory if life could adapt to very different conditions or if values of constants could compensate each other. Additionally, (2) it might be a result of chance or (3) it might be nonexistent because nature could not have been otherwise. With hopes of discovering a fundamental theory of everything all states of affairs in nature may perhaps be tautologous. Finally, (4) it may be a product of cosmic Darwinism, or cosmic natural selection, making the measured values quite likely within a multiverse of many different values.[4] The succeeding sections will be explications of the form of the argument and the competing hypotheses.

[4] Ibid., 4.

CHAPTER TWO: COMPETING HYPOTHESES

I. The Fine-Tuning Hypothesis

In this section I will argue that the form and methodology in making the FT argument requires careful attention and explication. The method of reasoning used for the argument should be presented in an abductive form. When put into an abductive form it can appear in several different versions. However, given the role of probability and the need for a formal structure I am advocating a modified version of Robin Collins':

1) Given the fine-tuning evidence, a life permitting universe/multiverse (LPM) is very, very unlikely under the non-existence of a fine-tuner (~FT): that is, P(LPM|~FT & *k*') ≪ 1.
2) Given the fine-tuning evidence, LPM is not unlikely under FT (the fine-tuner hypothesis): that is, ~P(LPM|FT & *k*') ≪ 1.
3) Therefore, LPM strongly supports FT over ~FT.

Remember that *k*' represents some appropriately chosen background information that does not include arguments for the existence of God, while merely *k* would encompass all background information, which would include the other arguments, and ≪ represents much, much less than (thus, making P(LPM|~FT & *k*') close to zero).[5]

A defense of premise (1) would simply require examples of fine-tuning and the options available. The argument has been bifurcated, which proposes a fine-tuner hypothesis and a non-fine-tuner hypothesis (~FT). I believe this is the most basic form of the first premise since FT encapsulates everything being argued for and ~FT includes any other attempt at explaining the data. Whether ~FT is chance, necessity, a combination of chance and necessity, or anything else ~FT sufficiently accounts for these types of explanations. In providing examples of the data and fine-tuning evidence the most modest and minimal case should be argued for, which I would

[5] Arguments for the existence of God taken in to the total background knowledge would certainly increase the probability for the existence of a fine-tuner. However, I want to keep the argument as modest as possible and in doing so I will exclude other apologetic arguments. Robin Collins, "The Teleological Argument," in *The Blackwell Companion to Natural Theology* Eds. William Lane Craig and J.P. Moreland (Oxford, UK: Blackwell, 2009), 207.

consider as the values of the laws of nature and the mechanisms[6] that allow the multiverse to function as it does. Premise (1) requires the truth of counterfactually reliable expressions of the laws of physics.[7]

There are two ways of understanding the definition of *fine-tuner*: a positive and negative definition. By fine-tuner in the positive sense I mean a mind, or agent, capable of articulating information (a specified and complex information). Not only would this mind be merely capable in articulating this information but also intended to articulate the precise information we find in nature.[8] The negative definition is the insufficiency of necessity, regularity, mindless chance, or any other combination of the sort as being the best explanation for the data. Note that a fine-tuner is distinct from a mere intelligence since intelligence can mimic regularity or chance, and thereby rendering its actions indistinguishable from regularity or chance.[9] Thus, it is important to recognize the combination of the two definitions, which serve different explanatory roles but are identical in reference.

In defense of premise (2), the best scientific evidence does suggest fine-tuning in the sense that counterfactual expressions of the values of laws and constants would not produce a

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[6] This will be discussed and greater detail and defended in Chapter 6 Section IV. For further reference the four mechanisms I am referring to are: (1) A mechanism to supply the energy needed form the bubble universes: The fine-tuning of the inflation field. (2) A mechanism to form the bubbles. The actual mechanism is Einstein's field equations + inflation field. (3) A mechanism to convert the energy of the inflation field to the normal mass/energy we find in our universe. The actual mechanism is $E=mc^2$ + coupling between the inflation field and matter fields. (4) A mechanism that allows enough variation in the constants of physics among universes (one of the predictions of quantum cosmology is random constants). The actual mechanism is superstring theory or M-theory. Collins, 263-267.

[7] An example of a counterfactually reliable expression of physics would be that if the value of the strong nuclear force were any stronger than its current observable value then there could not be complex atomic structures. Another example is that if the Pauli Exclusion Principle did not exist then atomic nuclei would suck in orbiting electrons.

[8] This will be discussed in further detail in Chapter 6 on the role and origin of information.

[9] William Dembski, *The Design Inference: Eliminating Chance Through Small Probabilities* (New York: Cambridge University Press, 2005), 36.

life permitting universe (LPU) or observers. The FT hypothesis is a religiously neutral position. If FT is true the identity of the fine-tuner cannot be known by FT alone. FT is perfectly compatible with a variety of religious beliefs.[10] The question is whether it is more reasonable to infer the existence of a fine-tuner to produce a product that exhibits fine-tuning or whether this happened by chance. If a multiverse scenario is being considered this method of argumentation and use of probability certainly allows for an infinite set of universes. Usually, given the sample size of an infinite set the probability of a life-permitting universe is precisely 1. However, as previously stated, it is the mechanisms that drive the random variations in the laws of physics that require fine-tuning. If a finite set is being considered, Andrei Linde and Vitaly Vanchurin recently published a paper suggesting that there are $10^{10^{10^7}}$ universes in the multiverse landscape as a product of inflation.[11] We know at least one universe that exhibits life that may have been randomly produced. Or, this could be a product of nomic necessity but there does not seem to be an account for explaining the nomic necessity as a logical or metaphysical necessity. A strong case would have to be made. It will be argued that such explanations are insufficient in the succeeding section.

The conclusion follows logically from the premises. This gets us to an extremely intelligent agent. The amount of information and values in one universe needs to be explained and the multiverse scenario provides more information to be explained. Thus, the evidence of

[10] I am assuming religious beliefs entail that the identity of that being worshiped is known and that there are corresponding dogmas and worship of the being. When arguing for design, the argument cannot take one to Christianity or even God. All one can purport is an intelligent cause. The evidence cannot identify who or what the cause is. This is constructive empiricism. Constructive empiricism states that one can only refer to the aspects of that being, in this case, the intelligence of the cause, respective to the issue and evidence at hand.

[11] Andrei Linde and Vitaly Vanchurin, “How Many Universes are in the Multiverse?” arXiv:0910.1589 (Oct. 2009): 10.

the fine-tuning we observe, the values of constants and laws of nature, is much, much more likely under the hypothesis that there is a fine-tuner.

II. The Non-Fine-Tuning Hypothesis

The ~FT has several different forms but, broadly speaking, is anything other than FT. There are three primary ~FT versions: chance, necessity, and chance and necessity. Each one has different explanatory strengths and weaknesses. In this section I will define the terms of the hypothesis. In chapters five and six I will elaborate on specific models of the respective hypotheses.

It is important to qualify this explanatory hypothesis of chance. Chance can appear as *mindless* chance or as a *finely-tuned* chance. Suppose that I have a pair of dice of which I have the ability to control what the values will be when rolled. There are two different ways I could do this. The first is to choose which value will appear for each die when thrown. If I choose two sixes then, when thrown, the dice land on two sixes. Perhaps I achieve this by placing small magnets in the dice and throw them on a magnetic table with an opposite pole so when the magnets attract the two sixes are on top. The second way I could control the values is by setting specified parameters. I could accomplish this by having the same magnets in the dice but have the table magnet with the same pole so the magnets repel forcing the dice to not land on a certain value. To give another illustration, suppose I cover the black 26 and the red 32 on a roulette wheel so the ball cannot land in those spots. By setting these parameters there is a purposive elimination of possible outcomes but the remaining outcomes would still be a product of chance. Thus, ~FT will refer to mindless chance.

Necessity, also known as necessitarianism (NT), attempts to account for the values of the laws of nature as nomic necessity. The necessitarian states that there are metaphysical connections of necessity in the world that ground and explain the most fundamental regularities. Necessitarian theorists usually use the word *must* to express this connection.[12] Thus, necessitarianism maintains *must*-statements are not adequately captured by *is*-statements (must ≠ is, or certain facts are unaccounted for).[13]

There is a slight distinction between the necessitarian position and a regularist position. Regularity theory (RT) states that the fundamental regularities are brute facts; they neither have nor require an explanation. Regularity theorists attempt to formulate laws and theories in a language where the connectives are all truth functional. Thus, each law is expressed with a universal quantifier as in [(x) (Px ⊃ Qx)].[14] C.D. Broad argued that the very fact that laws entail counterfactuals is incompatible with regularity theory.[15] He suggests that counterfactuals are either false or trivially true. If it is now true that Q occurs if P causally precedes Q then the regularist may sufficiently account for past counterfactual claims. Given the present antecedent condition of P at t_n and P implies Q at t_n and it was true that P implied Q at t_{n-1} and using P as an antecedent for R at hypothetical $t_{n-1'}$ then R is true if P was a sufficient condition R at $t_{n-1'}$. Thus, regularity accounts for past counterfactuals, but this is trivially true. However, in positive favor of necessitarianism, there is no reason to expect the world to continue to behave in a regular manner as presupposed by the practice of induction. The regularist may point out that generalizations from finite sample sets cannot be warranted unless the appropriate necessary

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[12] Robin Collins, "God and the Laws of Nature," *Philo* 12 no. 2 (2009): 2-3. (Preprint).

[13] Bernard Berofsky, "The Regularity Theory," *Nous* 2 no. 4 (1968): 316.

[14] Ibid., 315.

[15] C.D. Broad, "Mechanical and Teleological Causation," *Proceedings of the Aristotelian Society: Supplementary Volumes* (1935): XIV.

connections are postulated, which is this problem of induction.[16] This is a problem whose examination has often been the occasion for the introduction of necessitarianism. Unless a necessitarian is prepared to say that the relation of necessity is actually observed in the instances of some law, the inference to a necessary law creates the problem of induction just as easily.[17] The reason why this distinction between regularity theory and necessitarianism is so important is because there must be an appropriate random sample to make a probability argument from cosmology. These two positions are slightly different but both allow for counterfactual claims the proponent of ~FT is forced to commit to, which eliminates objections based on a claim of inappropriate random sampling.

A combination of chance and necessity may seem contradictory but the way it is used as an *explanans* allows for a harmonious compatibility. For example, consider the bio-chemical structure of a DNA strand, which is composed of a sugar-phosphate backbone and four different nucleotides as the rungs. Because of the chemical structure adenine always pairs with thymine and guanine always pairs with cytosine. Guanine and thymine bond in a DNA helix. This would be an example of the role of necessity. This chemical necessity combines with chance when we

[16] For example, consider gold having an atomic weight of 196.966543. This follows necessarily from gold's atomic structure but gold is contingent. With this being an analytic *a posteriori* claim there is no counterfactual claim that is true about the atomic weight. The law of alpha particle decay in the half-life of a uranium atom is purely probabilistic. The probability remains constant over time and is the same in every uranium atom, and there is no difference at all between two uranium atoms one of which decays and the other does not in the next minute. It is the case that introducing a laser into the atomic nucleus of ^{232}U, which alters the stability of the atom and accelerates the alpha and beta decay, can alter the rate of decay. However, the fact remains that *when* the decay occurs is determined by the quantum world of probability (depending on one's interpretation of quantum mechanics). In either of these two neither necessitarianism nor regularity theory provide a preferred explanation for such counterfactual states of affairs. Such counterfactual claims are empty with certain laws. Some may have counterfactual truth and others are vacuous. If one were to attempt to express such alpha decay as $[(x)\ (Px \supset Qx)]$, for every alpha particle, if an alpha particle of uranium obtains then the alpha particle will decay is true but cannot be causally or temporally indexed. Alex Rosenberg, *Philosophy of Science* (New York: Routledge, 2012), 92. A.V. Simakin and G.A. Shafeev, "Accelerated Alpha-Decay of ^{232}U Isotope Achieved by Exposure of its Aqueous Solution with Gold Nanoparticles to Laser Radiation," arXiv:1112.6276 (Dec. 2011), 1-2.

[17] Berofsky, 325-26.

consider the order of the sugar-phosphates. There is no chemical bond, which necessitates the order in which the sugar-phosphates are positioned vertically in the helix. A rung of adenine and thymine may be followed by a guanine and cytosine or it may simply be repeated. There is no chemical law requiring a specific order of the sugar-phosphate bonds. This is simply an example from biology. Examples can be given in physics and cosmology as well. For instance, Stephen Hawking argues that given the law of gravity (a necessity) a universe will form by happenstance (chance).[18]

The Princeton philosopher David Lewis and M.I.T. physicist Max Tegmark have postulated a metaphysical multiverse (MM) to account for the behavior of natural laws. Their proposed multiverse scenarios entail modal realism.[19] Under such a MM different regions of space will exhibit different *effective* laws of physics (i.e. difference constants, dimensionality, particle content, relation of information, information propagation, etc.) corresponding to different local minima in a landscape of possibilities.[20] This could obtain in several different ways such as the local bubble location in a string landscape or in unitary quantum physics the wave function does not collapse and all possibilities are actualized. Such an approach denies counterfactual definiteness. This means that any counterfactual of what measurements have not been performed are empty of any meaning and truth.

These MM scenarios allow for the proponents to get the *best of both worlds*. It avoids the problem of RT by having variance in the behavior of laws. A tropical fish never leaving the

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[18] See Stephen Hawking and Leonard Mlodinow, *The Grand Design* (New York: Random House, 2010), 173-81.

[19] This modal realism is, in a sense, modally limited. The state of affairs of the non-existence of anything cannot be true if something does exist so by definition modal realism must entail $\sim\exists!W$ with W being the non-existence of anything—nothing, lest it suffer the consequence of being intrinsically incoherent and thus requires a model akin to NT.

[20] Max Tegmark, "The Multiverse Hierarchy," arXiv:0905.1283v1 (May 2009): 1.

ocean might mistakenly conclude that the properties of water are universal, not realizing that there is also ice and steam. We may be smarter than fish but may just as easily be fooled.[21] This is a shortcoming of RT for all we know such regularities are localized instantiations. The problems of NT and RT are avoided but it takes on its own problem similar to the NT problem of accounting for the mechanisms that produce the varying laws and values.

[21] Ibid.

CHAPTER THREE: METHODOLOGY

I. The Logic of the Fine-Tuning Argument

The fine-tuning argument argues that when the physics and the laws of nature are expressed mathematically their values are ever so balanced in ways that permit the existence of life. This claim is made on the basis that existence of vital substances such as carbon, and the properties of objects such as stable long-lived stars, depend rather sensitively on the values of certain physical parameters, and on the cosmological initial conditions.[22] I am merely arguing that the universe/multiverse is fine-tuned for the essential building blocks and environments that life requires for cosmic and biological evolution to even occur. The argument has several different forms in contemporary literature. In this section I will present the argument in its deductive and inductive forms and offer criticism. Then abductive reasoning, or inference to the best explanation, will be assessed, along with the role of probability, and I will advocate this as the proper methodology and form for the fine-tuning argument.

The argument is *a posteriori* gathered from the natural sciences. The method by which design will be inferred is a historical science. There are four differences between a historical science and a laboratory science. First, repeatability is not applicable in the historical sciences; it is a metacriterion for laboratory science. Second, historical science assumes uniformitarianism, that is, there are presently known causes to phenomena, which can be inferred by perceived effects.[23] Third, the theories and explanatory hypotheses must lay in empirical harms way. The conclusions must be falsifiable. It should be noted that the *type* of scientific inquiry will be that of an Augustinian science as opposed to a Duhemian science. Augustinian science permits and

[22] Paul Davies, "How Bio-Friendly is the Universe?" arXiv:astro-ph/0403050v1 (March 2004), 1.

[23] The method of uniformitarianism is currently understood in the scientific community as an assumption of the regular course of events as well as catastrophism (which would be implied by the presently known cause and effect relationships).

carries open metaphysical presuppositions with science. Duhemian science strips science of all metaphysical imports. This point yields to the final distinction, which is the understanding that historical science must use non-controversial reasoning. The controversial claim for the FT proponent is simply the introduction of agent causation. However, this is not as controversial as much of the scientific community makes it out to be. Agency is publically accepted evidence by experience (this is not based on religious explanations or religious experience).

In the following sections I will examine problems with deductive and inductive arguments, which are most commonly used for fine-tuning arguments. I will then examine abductive arguments and argue that inference to the best explanation should be the preferred methodology for constructing FT arguments.

A. The Problem of Deduction

In a correct deductive argument if the premises are true the conclusion is true regardless of whether or no further evidence is considered. There must be a reasonable connection or relationship between the conditions in a deductive argument (in the instance of implication). Consider the argument, as *modus ponens*, that if the moon's core is made of cheese then my desk is made out of mahogany. What relationship do these two conditions have? The truth-value is valid (F-T-T). However, I recognize that this is merely a preference, which is, at times, convenient. When making a novel *explanans* and prediction the relationship between the conditions may not be epistemically evident.

There are generally three options, which are often considered as an explanation for the fine-tuning data: chance, necessity, a combination of chance and necessity, or a fine-tuner. One immediate problem in implementing explanatory options in a deductive manner is that the first premise may be false wherein it may be lacking in options and the argument still is valid. When these options are used in a [strict] deductive argument[24] it may appear as:

1) The fine-tuning of the universe is due to either physical necessity, chance, or design.
2) It is not due to physical necessity or chance.
3) Therefore, it is due to design.[25]

From the very onset of the argument it may be unsound. Perhaps there are more options to be considered in premise 1. It would still be valid but how strong of an argument, or how convincing, would it be if the options given were restricted? An objector could merely appeal to an option not given, whatever that may be, perhaps 1 is not exhaustive or nuanced enough, and the argument rests stillborn from the very beginning.

In regards to this specific argument, if the hypothesis of *mindless* chance processes entailed that it is impossible that cosmic environments are brought about to allow for biological evolution to occur and for organisms exhibit delicate adaptations, then a quick application of *modus tollens* would sweep that hypothesis from consideration by merely positing not-mindless chance. However, it is not impossible that mindless chance processes should produce cosmic environments suitable for cosmic evolution and biological evolution to occur. It is merely improbable that such conditions should be brought about.[26] The manner in which Craig presents this argument has a hidden premise of induction or abduction. The problem is that it is not clear. This hidden premise could be taken as induction or abduction and with no explication it weakens the case more than it already was by setting it up in a deductive manner.

[24] An abductive argument may appear in a deductive manner (i.e. disjunctive) but that does not necessitate that it *is* a deductive argument. I am using the word 'strict' to indicate the difference between forming the abductive argument in a similar structure and an actual deductive argument.

[25] Design could be exchanged for fine-tuning. William Lane Craig uses this form of the argument in *Reasonable Faith* Ed. 3 (Wheaton, IL: Crossway, 2008), 161.

[26] Elliott Sober, "The Design Argument," in *God and Design* Ed. Neil A. Manson (New York: Routledge, 2003), 33.

B. The Problem of Induction

For example[27], it is possible to show that the series 1 + 2 + 3 + 4 + … has a sum of n terms of n(n + 1)/2. First one must show that if it is true for n terms it must also be true for (n + 1) terms. According to the formula

$Sn = n(n + 1)/2$

if the formula is correct, the sum of (n +1) terms is obtained by adding (n +1) terms is obtained by adding (n + 1) to this

$Sn+1 = n(n + 1)/2 + (n +1)$

$Sn+1 = n(n + 1)(n + 2)/2$

This agrees with the result obtained by replacing n in the general formula by (n + 1), i.e.:

$Sn+1 = n(n + 1)(n + 1 + 1)/2$

$Sn+1 = n(n + 1)(n + 2)/2$

Thus, the formula is true for (n + 1) terms if it is true for n terms. Therefore, if it is true for the sum to one term (n = 1), it must be true for the sum of two terms (n + 1). Likewise, if true for two terms, it must be true for three terms, and so on through all the values of n. It is easy to show that it is true for one term:

$Sn = (1 + 1)/2$

$Sn = 1$

which is the first term in the series. Hence, the theorem is true for all integer values of n.

In logic, induction takes individual instances and applies them to more general instances (or, particularly, taking an existential instantiation and turning that into a general instantiation), or from observed to unobserved ones. Induction usually takes the form: F1 is A, F2 is A… Fn is A,

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[27] This example can be found in John Daintith and John Clark's *The Facts on File Dictionary of Mathematics* (New York: Market Book House, 1999), 96.

therefore all Fs are A (‘this swan has wings, that swan has wings… therefore all swans have wings’); or: all Fs observed so far are A. Unlike deduction, asserting the premises while denying the conclusion in an inductive argument does not lead to a contradiction. The conclusion is not guaranteed to be true if the premises are true.

Inductive logic, generally speaking, takes elements of a set and applies this subset of elements to a broader set. More specifically, the principle of mathematical induction states that if zero has a property, *P*, and if whenever a number has the property its successor also has the property, then all numbers have the property:[28]

$$(\forall P)(((P(0)\,\&\,(\forall x)((x\in N\,\&\,Px)\rightarrow(\forall y)(y\in N\rightarrow Py))$$

Induction works by enumeration: as support for the conclusion that all *p*’s are *q*’s, one could list many examples of *p*’s that are *q*’s. It also includes an ampliative argument in which the premises, while not entailing the truth of the conclusion, nevertheless purport good reason for accepting it.[29]

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[28] A.D. Irvine, “The Philosophy of Logic” in *Philosophy of Science, Logic and Mathematics in the Twentieth Century* (New York: Routledge, 2000), 13.

[29] Ibid., 389. As I’ll note, one of the reasons why induction is supported entails a reason for why induction is weakened as an explanatory methodology. All induction problems may be phrased in a way that depicts a sequence of predictions. Inductive problems will contain a previous indicator or *explanans* for the *explanandum*. For instance, Carl Hempel’s example of Jones’ infection:

$$\begin{array}{l} p(R,S\,\&\,P) \\ \underline{Sj\,\&\,Pj} \\ \hline Rj \end{array}$$

Where *j* is Jones, *p* is the probability, *Sj* is Jones’ infection, *Pj* is he being treated with penicillin, and *Rj* is his recovery. If the probability of observing *R* at any time given the past observations of $S\&P_1$… $S\&P_2$ … $S\&P_n$ (the probability of the set meeting *R* is *m*) where *R* was close to 1 then a predictive *explanans* (the $S\&P_n$) can be made for future instances of *m* using an inductive-statistical explanation. For if the probability $m(S\&P_n \mid S\&P_1\ldots\ S\&P_2\ \ldots)$ is a computable function, the range of data is finite then a posterior predication *M* can be made from *m*. *M* can be legitimately referred to as a universal predictor in cases of *m*. This is where Hempel rejects the requirement of maximal specificity (RMS), contra Rudolph Carnap, in which the RMS is a maxim for inductive logic that states that this is a necessary

However, there is a great deal of problem for induction when applied to the fine-tuning argument. The fine-tuning argument can be expressed inductively if the premises make the conclusion probable. An inductive form of the argument typically appears somewhat similar to William Paley's argument from design.

1) Entity *e* in nature, or nature itself, is *like* specified human artifact *a* in relevant properties *p*.
2) *a* has *p* precisely *because* it is a product of deliberate design by intelligent human agency.
3) *Like* effects typically have *like* causes or *like* explanations.
4) Therefore, it is probable that *e* has *p* precisely because it too is a product of deliberate design by intelligent, relevantly human-*like* agency.[30]

This analogizes known instances of design, such as the design of a watch, a computer, or a light bulb, with the similarities of the natural phenomena to be explained (i.e. DNA, the function of certain equations, etc.). Expressed inductively, for every element in a set of properties in which these properties are compared to the properties of known and observed designs there is a subset of properties that have similar properties. One of the problems is determining the line of demarcation between how many similarities warrant for concluding that there is design (or fine-

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condition for rationality of any given knowledge situation *K*. Let *K* represent the set of data known in *m*. According to Hempel we cannot have *all* the material for *K*. For any future time when the *explanandum* is in sync with the *explanans* of *K*, in this case, *Rj*, may be different when factoring different data at different times. It may be the case that future data that was impossible to consider may bring about ~*Rj*. I believe Carnap's RMS should be understood as a principle rather than an axiom for inductive logic. It seems RMS is an attempt to make inductive arguments like deductive arguments. So, instead of using *M* as a universal instantiation of future *m*, *M* may simply be a categorical similarity of *m* as a mere prediction and only a prediction because it is tentative to future variations of like-conditions in future *explanandums*. I know Carnap would suggest that his system of inductive logic there can be a degree of confirmation of statements which assign an inductive probability to a hypothesis about a particular event relative to the evidence statements about other particular events and that no universal generalizations are involved. Carl G. Hempel, "Inductive-Statistical Explanation" in *Philosophy of Science*. Eds. Martin Curd and J.A. Cover (New York: Norton, 1998), 706-708. Marcus Hutter, "On the Existence and Convergence of Computable Universal Priors," *Technical Report* 5 no. 3 (2003): 1-3. Wesley Salmon, "Hempel's Conception of Inductive Inferences in Inductive-Statistical Explanation," *Philosophy of Science* 44 no. 2 (1977): 183.

[30] This is a similar to the form used by Del Ratzsch, "Teleological Arguments for God's Existence" in *The Stanford Encyclopedia of Philosophy (Spring 2012 Edition),* Ed. Edward N. Zalta. plato.stanford.edu/archives/spr2012/entries/teleological-arguments (accessed April 23, 2012).

tuning) and how much dissimilarity warrants not-design. Additionally, there must be a distinction in what is the appropriate margin for categorizing a property as similar—this asks the question, "How similar are these properties?"—and the distinction for what property is dissimilar. In known instances of design we can know that final causation has occurred when a light bulb is designed because it was evidently designed to fulfill the purpose of illumination. In attempting to demonstrate final causation the inductive argument one *must assume* final causation if any criterion of 'function' is to be compared. This problem is akin to the requirement of maximal specificity. Though this does not completely eliminate the power of any fine-tuning argument, when it is formatted with the premises supporting the conclusion it is a weaker version for a historical method of inquiry.

C. The Robustness of Abduction

An abductive argument for fine-tuning is very similar to induction. Rather than the premises adding to the probability of the conclusion the conclusion adds to the probability of the premises. This is not to completely exclude the role of the premises adding to the probability of the conclusion but there is a greater emphasis of using the best explanation (the conclusion) to fit the data (the premises). The belief in question is assessed as the consequent and then considering what may be the best explanation for that belief, antecedently. This may seem fallacious but inference to the best explanation (IBE) is a commonly accepted form of reasoning. Additionally, this abductive process only comes into the process when assessing whether the evidence sufficiently corresponds to the belief since the belief typically arises by the antecedent evidence and then as the consequent, it is the assessment of the belief that requires working backwards.

Such methods are derived from the use of abductive reasoning. The American philosopher and logician Charles Sanders Peirce first described abduction. He noted that, unlike inductive reasoning, in which a universal law or principle is established from repeated observations of the same phenomena, and unlike deductive reasoning, in which a particular fact is deduced by applying a general law to another particular fact or case, abductive reasoning infers unseen facts, events, or causes in the past from clues or facts in the present.[31] Consider the following syllogism:

1) *If it rains, the streets will get wet.*
2) *The streets are wet.*
3) *Therefore, it rained.*

Here, the use of abductive reasoning may seem fallacious at first take. This syllogism seems to commit the fallacy of affirming the consequent. One cannot deduce from the data, that the streets are wet, that it rained because there are many other explanations for why the streets are wet. It could have been the case that a fire hydrant was allowed to flow, a street cleaner came through, a concerned citizen who wanted to clean the chalk off of the streets from the little children drawing pictures or writing words. There are many possibilities that could explain why the road was wet. This was the problem posed before Peirce. How was it that despite the logical problem of affirming the consequent, one nevertheless frequently makes conclusive inferences about the past? The key point is the explanatory scope and power of the explanation. Abductive reasoning does not derive a certain conclusion (for one would then be guilty of affirming the consequent), but it makes an *inference to the best explanation*. Peirce's example was whether anyone should believe in the existence of Napoleon. He claimed that the past may be inferred from the study of present effects, namely, artifacts and records. Peirce concluded, "Though we

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[31] In the words of Stephen C. Meyer, *Signature in the Cell* (New York: Harper Collins, 2009), 153. Charles Peirce, *Collected Papers*, 2:375; "Abduction and Induction."

have not seen the man [Napoleon], yet we cannot explain what we have seen without the hypothesis of his existence."[32] Despite the apparent fallacy, W.P. Alston, W.B. Gallie, and Michael Scriven have observed, such arguments can be restated in a logically acceptable form if it can be shown that *Y* has only one cause (i.e. *X*) or that *X* is a necessary condition (or cause) of *Y*. Thus, arguments of the form:

1) *X is antecedently necessary to Y*,
2) *Y exists*,
3) *Therefore, X existed*.

are logically valid by philosophers and persuasive by historical and forensic scientists.[33] Its application to this case is that a particular abductive hypothesis can be firmly established if it can be shown that it represents the best or only explanation of the "manifest effects" in question.[34] Whatever the best explanation is it cannot be contrived *ad hoc* or *post hoc* but must be related to the evidence and must follow *from* the evidence. Abduction allows for a powerful predictive capability. Abductive reasoning allows for the positing of the best explanation, which may lie beyond, external to, the data. The conclusion does not rest in any of the premises.

This is a non-controversial use of reasoning. Many inferences are naturally described in this way. Charles Darwin inferred the hypothesis of natural selection because although his biological evidence did not entail it, natural selection would provide the best explanation of that evidence. Astronomers use abduction when they infer that a galaxy is receding from the Earth

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[32] Charles Sanders Peirce, "Abduction and Induction" in *The Philosophy of Pierce*, Ed. J. Buchler (London: Routledge, 1956), 375.

[33] Stephen C. Meyer, "A Scientific History—and Philosophical Defense—of the Theory of Intelligent Design." W. P. Alston, "The Place of the Explanation of Particular Facts in Science," *Philosophy of Science* 38 (1971): 13-34. W. B. Gallie, "Explanations in History and the Genetic Sciences" in *Theories of History: Readings from Classical and Contemporary Sources* (Glencoe, IL: Free Press, 1959), 386-402. Michael Scriven, "Explanation and Prediction in Evolutionary Theory," *Science* 130 (1959): 477-482.

[34] Meyer, *Signature in the Cell*, 154.

with a certain velocity because the recession would be the best explanation of the redshift the light from the galaxy emits.[35] Inference to the best explanation is in close contact with the holistic view of explanation.[36] Philip Kitcher argued that this holistic view of inferential reasoning

> [h]olds that [scientific] understanding increases as we decrease the number of independent assumptions that are required to explain what goes on in the world… Explanations serve to organize and systematize our knowledge in the most efficient and coherent possible fashion. Understanding, on this view, involves having a world-picture—a scientific *Weltanschauung*—and seeing how various aspects of the world and our experience of it fit into that picture.[37]

II. The Role of Probability

The most common way to connect confirmation with probability is by adopting the relevance criterion of confirmation, according to which a piece of evidence, *e*, confirms a hypothesis, *h*, if and only if *e* raises the probability of *h*:

> *e* confirms *h* if and only if $P(h|e) > P(h)$;
> *e* disconfirms *h* if and only if $P(h|e) < P(h)$.[38]

In other words, whenever we are considering two competing hypotheses, an observation counts as evidence in favor of the hypothesis under which the observation has the highest probability.[39]

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[35] Peter Lipton, "Abduction," in *The Philosophy of Science*, Eds. Sahorta Sarkar and Jessica Pfeifer (New York: Routledge, 2006), 1.

[36] Philip Clayton, "Inference to the Best Explanation," *Zygon* 32 no. 3 (1997): 387.

[37] Philip Kitcher, "Scientific Explanation," *Minnesota Studies in the Philosophy of Science* 13 (1989): 182.

[38] Curd and Cover, 627.

[39] Sometimes the relevance criterion of confirmation is referred to as the prince principle of confirmation or the likelihood principle. Let h_1 and h_2 be two be competing hypothesis (in this case the existence of X and ~X, with X being a first cause, fine-tuner, etc.). According to the relevance criterion of confirmation, an observation *e* counts as evidence in favor of hypothesis h_1 over h_2 if the observation is more probable under h_1 than h_2. Thus, *e* counts in favor of h_1 over h_2 if $P(e|h_1) > P(e|h_2)$, where $P(e|h_1)$ and $P(e|h_2)$ depict a conditional probability of *e* on h_1 and h_2, respectively. The degree to which the evidence counts in favor of one hypothesis over another is proportional to the degree to which *e* is more

For example, complex and specified information (*e*) confirms the hypothesis that a fine-tuner exists (*h*) if and only if it is more probable that a fine-tuner exists given complex and specified information over the probability of the mere existence of a fine-tuner.

This principle is sound under all interpretations of probability. The relative criterion of confirmation can be derived from the so-called odds form of Bayes' Theorem, which also allows one to give a precise statement to the degree to which evidence counts in favor of one hypothesis over another. The odds form of Bayes' Theorem is:[40]

$$P(h_1|e)/P(h_2|e) = [P(h_1)/P(h_2)] \times [P(e|h_1)/P(e|h_2)]$$

Whenever probability is being considered there must be some type of relevant or total background information (usually depicted as *k*). In the final form of the argument the background information will be represented as *k*', which excludes arguments for the existence of God. Since this argument cannot render the conclusion that God exists such arguments should not be considered relevant to the probability calculus.

A problem that is often raised when using the relevance criterion of confirmation or Bayesian-type analysis is that if evidence *e* is included in the background information *k*, then even if a hypothesis *h* entails *e*, it cannot confirm *h* since $P(e|k \,\&\, h) = P(e|k \,\&\, {\sim}h)$.[41] For instance, if *k* includes evidence *e* that we exist then it would certainly be the case that *h* entails *e*. However, as previously noted, if $k' = k - \{e\}$ then *k'* must denote a background information that excludes all arguments for the existence of God and types of anthropic arguments. For instance, if *k'* were to include *e* such that *e* was a cosmological argument from contingency then the total

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probable under h_1 than h_2: particularly, it is proportional to $P(e|h_1)/P(e|h_2)$. Collins, "The Teleological Argument," 205.

[40] Ibid.

[41] Ibid., 241.

background knowledge will be exponentially increased since the first uncaused caused will increase the probability of an antecedent mind responsible fro the fine-tuning of physics. Concerning anthropic arguments, *k'* should not include the datum that we exist since it would then entail that LPU.[42] This problem of old evidence appears in a more simplified scenario: given a certain characterization of background information *B*, the objective value of P(*E*|*B*) must always be 1. Since *B* includes all the details about the experimental setup and the instruments used to observe *E*, the objective probability that *B* will occur under those conditions (assuming that the system in question is deterministic) is 1.[43]

An immediate objection when applying a probability rule or calculus to the fine-tuning argument states that we do not have an appropriate random sampling. In other words, if we know of only one universe the random sample size is precisely 1; thus, no random sample can be used to assess the probability of certain values of physics in the argument. In statistics a random sample drawn must have the same chance of being sampled as all the other samples. Since we know of only one universe we do not know what the range of values for the constants and physics could be. Additionally, since we do not know how narrow or broad these ranges could be there is no way of drawing out any probability based argument from fine-tuning. However, we can know what other universes would be like if the values were different. If our natural laws have counterfactuals that are in any way coherent then this is an appropriate sampling. Also, to make this objection and advocate that we just so happen to live in a life permitting universe in the multiverse then this objection cannot be made since the claim that we happen to life in a life-permitting one amongst countless others suggest we can know what the other samplings are. For

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[42] Ibid.

[43] Martin Curd and J.A. Cover, "The Expectedness of Evidence," *Philosophy of Science* Eds. Martin Curd and J.A. Cover (New York: Norton, 1998), 643.

instance, if the strong nuclear force were any stronger the universe would be composed of only hydrogen and if gravity were any weaker stars could never form to create the heavier elements. If these counterfactuals are coherent and are possible then we can draw an appropriate random sample. Also, note that we do not have to know how narrow or broad the range of values could be. That does not matter. It could be very narrow or extremely broad and this sampling would still be appropriate.[44] Thus, by virtue of the possible counterfactual expressions of the values of the laws of nature I believe we can make an appropriate probability based abductive argument for FT.

III. Duhemian Science and Methodological Naturalism

When considering the use of abductive reasoning in science there is an assumption, or suppressed premise, of scientific realism or critical realism. The limits of observation are a subject for empirical science, and not for philosophical analysis.[45] Thus, a theory is empirically adequate if and only if what it says about the observable things and events in this world is true. This methodology does not negatively affect the conclusion for the fine-tuning argument either.

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[44] What may be argued for is the mechanism that produces these random constants. This mechanism would be superstring theory or M-theory. Even though there may be a huge number of possible universes lying within the life-permitting universe, region of the cosmic landscape, nevertheless that life-permitting region will be unfathomably tiny compared to the entire landscape. This also shows that the physical universe itself is not unique. The physical universe does not have to be the way it is: it could be been otherwise functioning under different laws. Paul Davies, *The Mind of God* (New York: Simon & Schulster, 1992), 169. Davies means the laws of physics within the actual values of the constants, not confusing there being different values of the constants with there being different laws. Although some of the laws of physics can vary from universe to universe in M-theory, these fundamental laws and principles underlie M-theory and therefore cannot be explained as a multiverse selection effect. Further, since the variation among universes would consist of variation of the masses, and types of particles and the form of the forces between them, complex structures would almost certainly not be atomlike and stable energy sources would almost certainly require aggregates of matter. Thus, the said fundamental laws seems necessary for there to be life in any of the many universes, not merely in a universe with our specific types of particles and forces. Collins, "The Teleological Argument," 277.

[45] Bas van Fraassen, *The Scientific Image* (Oxford: Oxford University Press, 1980), 56.

The conclusion itself may be contested but this methodology may certainly be compatible with a realist empirical methodology (*a la* Darwin).

The French philosopher Pierre Duhem (1861-1916) was a prominent contributor to the realist and anti-realist debate who served as a catalyst for the future development of constructive empiricism (CE), form of anti-realism or critical non-realism. Duhem argued that scientific theories cannot be taken as literal descriptions of reality because theoretical descriptions are idealized in a way that the world is not.[46]

Empiricism set limits on what one is rationally obligated to believe. There is no commitment, under CE, to believe the truth of the theory but one can accept the empirical data. This is very modest in its commitment to the informative power of a theory. If one chooses an informative theory over a less committal counterpart then it can only be for pragmatic reasons and not because these theories are more likely to be true. According to CE, scientists need never accept the need to postpone theories [due to the need of more evidence] or use inferential methods such as abduction as forcing them to go beyond the limits of observation. The explanation of the data can never have a legitimate inference to the best explanation outside of the evidence.

Duhem also stripped any explanation metaphysical import from explanatory hypotheses. This meant the removal of agent causation from acceptable scientific data and since his methodology does not allow for the explanation to go beyond the data, *contra* abduction, agency was not permitted as a viable scientific explanation. If the aim of a physical theory is to explain phenomena in terms of the ultimate nature of their causes then physical science becomes

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[46] A.F. Chalmers, *What Is This Thing Called Science?* Ed. 3 (Indianapolis, IN: Hackett, 1999), 241-42.

subordinate to metaphysics and is no longer an autonomous science.[47] Due to the very nature of this approach it entailed methodological naturalism, which is only allowing physical entities to be considered scientific.

Realism holds the position that observable and unobservable entities actually exist. Mathematical theories can provide direct insight to the nature of reality. Anti-realism merely suits the data by positing an explanation but does not really say anything about how the world really is. Examining the scientific validity of certain types of theories, in particular multiverse scenarios, and assessing what those theories might imply for the nature of reality, is one in which one's philosophical approach leads to considerably different conclusions.[48] As previously noted, I am approaching science as a realist. If these multiverse scenarios are actually true then they accurately describe the physical reality.

Using theoretical entities (i.e. a mind) in any justificatory capacity for knowledge seems to fall short on W.V.O. Quine's naturalized epistemology (akin to Duhem's methodology). I think Quine does well in pointing out the problem with justificatory criteria for logical positivists but I do not think he offers a plausible solution. Additionally, it is difficult consider Quine as an empiricist by his denial of the two central dogmas: the distinction between analytic and synthetic statements and the distinction between empirical content and logical form for statements. The Quinian holistic approach of meaning applies to the meaning of a theory's terms given by their place or role in a theory. Then there is not a mere philosophical explanation for underdetermination but a philosophical foundation for incommensurability as well. Everything

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[47] J.P. Moreland, "The Physical Sciences, Neuroscience, and Dualism," in *The Nature of Nature*, 843.

[48] Brian Greene, *The Hidden Reality: Parallel Universes and The Deep Laws of The Cosmos* (New York: Knopf, 2011), 168.

was contained within a theory; it was completely autonomous. Observation was used by Quine to for pragmatic purposes that retained for science its claims of objectivity.[49]

Quine simply wants to treat theoretical entities as objects of perception but only in the pragmatic holistic fashion. Observation becomes empirical content as well as intersubjective checkpoints in science. Hypotheses imply observation categoricals. These are generalized conditionals of observation sentences (i.e. Whenever there is an apple then it is red)—the rejection of existential instantiation.[50] (This is where CE works best with a naturalized epistemology. Scientific and epistemic direct realism are compatible but are less pragmatic or tentative.)

The reason why Duhem's methodology should be rejected is because of the robust explanatory power of realism and abduction as well as the legitimacy of agency in a scientific hypothesis. This scientific methodology is known as Augustinian science, after St. Augustine. The Augustinian approach to science eschews methodological naturalism and employs religious or metaphysical commitments.[51] One need not import any religious commitments to the fine-tuning argument. However, the argument does require the metaphysical commitment to agency. Also, note that the argument still works given a CE approach. A stronger case for FT can be made using Augustinian science but the FT argument can stand on common ground of Duhem if need be given CE and the treatment of theoretical entities (mind) as pragmatic tools. Agency, or mind, is important since it will serve as the explanation for the origin of information in the universe, which will be discussed in chapter six.

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[49] Rosenberg, 241.

[50] Ibid.

[51] Moreland, 843.

CHAPTER FOUR: THE MULTIVERSE HYPOTHESIS

I. The Historical Development

In this section I will trace the history of the multiverse hypothesis, as depicted in its contemporary understanding,[52] to demonstrate that the multiverse is not *ad hoc* conjecture and that there is a strong scientific and philosophical basis for postulating many universes. In 1956 Hugh Everett III published his Ph.D. dissertation titled "The Theory of the Universal Wave Function." In this paper Everett argued for the relative state formulation of quantum theory and a quantum philosophy, which denied wave collapse. Initially, this interpretation was highly criticized by the physics community and when Everett visited Niels Bohr in Copenhagen in 1959

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[52] The idea of many universes traces back much further than Hugh Everett to the Pre-Socratics. They were known as the *sophos* (the wise ones). They were eclipsed by the British and German philosophers of science in the seventeenth century and were largely disconnected from science henceforth. Science sets the agenda, but philosophers bring philosophical reasons instead of scientific reasons. Science answers the questions. The Pre-Socratics were the first to deal with metaphysics and did so to provide a rational philosophy. This allowed for a rational and objective observation and the use of reason to systematize and order the content to make it coherent.

The Sophists were worldly-wise in contrast with the *sophos*–frustrated by the plurality of answers in the current philosophy. The Sophists were the original skeptics as evidenced in Pyrrho. They came out of the sixth century BC and broke away from religious dogma, which had never happened before. Their methods were pragmatic and subjective–rhetorical and fashionable. The phrase, "The One and the Many" became important. The One (reality) had everything related to it (Many). This is where we get Monism–the quality of oneness. We see Monism appear later in Leibniz's monads, which take us to a single substance and leads to atomic theory.

Ionian cosmology picked up the discourse. The poet Hesiod promoted a moral consistency with the gods and the Milesians used this as the next step of consistency to get to the natural order. Thales (624-546 BC) is often referred to as the first philosopher when he predicted an eclipse of the sun. This was the first step in the evolution of metaphysical discovery. (Thales' theorem postulated that if angles *A* and *C* were the diameter of a circle then angle *B* was a right angle.) The world was rational and could be predicted and ordered.

Anaximander (611-547 BC) was Thales' pupil. The Aperion was considered to be the intermediate boundaries of the heavens. Reality must be more fundamental than water (*a la* Thales). The Apeiron was in eternal motion. Anaximander postulated many universes. Universes are always in the mode of creation and destruction. This was very naturalistic–the universe was its own cause. *It was through Anaximander we first see the theory of evolution*. The Earth was believed to be a cylindrical column. Since it's on the center it does not fall. This principle was applied to matter. Democritus took these principles and applied it to the atom itself. Democritus believed there we an infinite number of universes being created and being destroyed at every moment.

Bohr was unimpressed with Everett's most recent development.[53] In 1957 Everett coined his theory as the Many Worlds Interpretation (MWI) of quantum mechanics. In an attempt to circumvent the problem of defining the mechanism for the state of collapse Everett suggested that all orthogonal relative states are equally valid ontologically.[54] What this means is that all-possible states are true and exist *simultaneously*.

Everett left the field of pure physics and went on to work for the Department of Defense until is untimely death in 1982. Since his seminal work many have had their reserves due to the mere weirdness. B.S. DeWitt, whose work was critical for Everett, stated,

> [I] still recall vividly the shock I experienced on first encountering this multiworld concept. The idea of 10^{100} slightly imperfect copies of oneself all constantly spitting into further copies, which ultimately become unrecognizable, is not easy to reconcile with common sense. Here is schizophrenia with a vengeance.[55]

However, there are still those who find the interpretation attractive. The Oxford philosopher David Wallace puts it this way:

> [I]n recent work on the Everett (Many-Worlds) interpretation of quantum mechanics, it has increasingly been recognized that any version of the interpretation worth defending will be one in which the basic formalism of quantum mechanics is left unchanged. Properties such as the interpretation of the wave-function as describing a multiverse of branching worlds, or the ascription of probabilities to the branching events, must be emergent from the unitary quantum mechanics rather than added explicitly to the mathematics.[56]

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[53] Jonathan Allday, *Quantum Reality: Theory and Philosophy* (Boca Raton, FL: Taylor & Francis, 2009), 439.

[54] An orthogonal state is one that is mutually exclusive. A system cannot be in two orthogonal states at the same time. As a result of the measurement interaction, the states of the observer have evolved into exclusive states precisely linked to the results of the measurement. At the end of the measurement process the state of the observer is the sum of eigenstate—or a combination of the sums of eigenstates, one sum for each possible value of the eigenvalue. Each sum is the relative state of the observer given the value of the eigenvalue. Allday, 442-43.

[55] Quoted in Allday, 455.

[56] David Wallace, "Everettian Rationality: Defending Deutsch's Approach to Probability in the Everett Interpretation," arXiv:quant-ph/0303050v2 (Mar. 2003): 1.

MWI was initially attractive, and still is, due to its appeasement of objectivity. There are no logical holes in the mathematics. It has recently gained greater popularity due to its present and greatest advocate Max Tegmark. In the following sections I will explicate Tegmark's categories of the multiverse and how these specifically relate to the issue of fine-tuning.

II. Max Tegmark's Hierarchy

Contemporary physics seem to indicate that there are good reasons, theoretically and physically, for an idea that there is a plurality of worlds. This concept has come to be understood as the multiverse. The multiverse is not monolithic but it is modeled after the contemporary understanding of an inflationary model of the beginning of this universe. Max Tegmark has championed the most prominent four-way distinction of the multiverse.[57]

Tegmark's first version of the multiverse is called the level one multiverse. The level one is, for the most part, more space beyond the observable universe. So, theoretically, if we were to go to the "edge" of the universe there would be more space. Having this model as a version of the multiverse may be misleading because there is still only one volume, landscape, or system involved. A generic prediction of cosmological inflation is an infinite space, which contains Hubble volumes (what we see in our universe) realizing in all conditions—including an identical copy of each of us about $10^{10^{29}}$ meters away.[58]

The level two multiverse is typically associated with other bubble universes spawning from a cosmic landscape and inflation. This version predicts that different regions of space can exhibit different laws of physics (physical constants, dimensionality, particle content, etc.)

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[57] Tegmark, "The Multiverse Hierarchy."

[58] When Tegmark refers to an "identical" copy he simply refers to a similar copy. There is a genuine ontological distinction. Ibid., 2.

corresponding to different localities and a landscape of possibilities.[59] Imagine the multiverse as a bathtub filled with tiny bubbles. Each bubble in this larger system (the bathtub) is a single universe. Or, imagine a pot of boiling water. The bubbles arise from the bottom of the pot analogous to the way inflationary cosmology works. These other domains (or bubble universes) are nearly infinitely far away in the sense that we could never get there even if we traveled faster than the speed of light (due to the constant stretching of space and creation of more volume).[60] It may, however, not be the case that there is an infinite set of universes. Andrei Linde and Vitaly Vanchurin have argued that the way slow-roll inflation works it could only produce a finite number of universes. Hence, they propose that there are approximately $10^{10^{10^7}}$ universes.[61]

The level three multiverse is particular to certain interpretations of quantum mechanics such as Hugh Everett's Many Worlds Interpretation. It is a mathematically simple model in support of unitary physics. Everything that can happen in the particle realm actually does happen. Observers would only view their level one multiverse, but the process of decoherence—which mimics wave function collapse while preserving unitary physics—prevents them from seeing the level three parallel copies of themselves.[62]

The fourth level is the all-encompassing version where mathematical existence is equivalent to physical existence. Mathematical structures are physically real and the entire

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[59] Ibid.

[60] Ibid., 7. Additionally, there has been good scientific evidence suggesting observational grounds for inflation. Researchers have taken the 7-year WMAP data and applied certain algorithms to pick up traces of thermal fluctuations in the early universe. What they found were traces of what could be bubble collisions of the edges of our universe with another universe. Stephen Feeney, et al., "First Observational Tests of Eternal Inflation: Analysis Methods and WMAP 7-year Results," arXiv:1012.3667v2 (July 2011).

[61] Linde and Vanchurin, 10.

[62] Tegmark, "The Multiverse Hierarchy, "10.

human language we use to describe it is merely a useful approximation for describing our subjective perceptions. Other mathematical structures give different fundamental equations of physics for every region of reality.[63] This would be Plato's ideal reality.

What is most important about having this scientific evidence is that it provides us with reasonable evidence to support the idea of modal realism. Modal realism cannot simply be brushed off anymore as being incoherent and baseless whereas this evidence may be an example of when purely mathematical, scientific, and philosophical theories may have physical support. Additionally, each version of the multiverse allows for modal realism to be true.[64] The following sections will examine the cosmogony of different levels and versions of the multiverse.

III. Inflationary Cosmology

Inflationary cosmology typically refers to L1M and L2M. This will be important when considering the variation of values for physical constants. The properties of our universe appear to be finely-tuned for the existence of life. Cosmologists would like to explain the numbers and values that describe these properties we observe. Their attempt is to show that these constants and values in nature are completely determined as a product of inflation.[65]

The eternally inflating multiverse is often used to provide a consistent framework to understand coincidences and fine-tuning in the universe we inhabit.[66] This theory primarily

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[63] Ibid., 2, 12-13.

[64] Whether Linde and Vanchurin are correct in their finite version of the multiverse or whether Tegmark is correct is irrelevant to modal realism. All that is required is that there be a time at which all possible states of affairs do occur—all events must not be simultaneous for modal realism to work. However, I am not necessarily arguing that the multiverse and modal realism are actually true.

[65] John D. Barrow, *The Constants of Nature: The Numbers Encode the Deepest Secrets of the Universe* (New York: Random House, 2003), 182.

[66] Alan Guth and Yasunori Nomura, "What Can the Observation of Nonzero Curvature Tell Us?" arXiv:1203.6876v2, (July 2012): 32.

appears several forms, which attempt to explain the mechanism that drives the rapid expansion of the universe. Before developing these models there are a few basic premises that must be agreed upon: the size of the universe, the Hubble expansion, homogeny and isotropy, and the flatness problem.

It is unanimously agreed upon that the Hubble volume we inhabit is incredibly large. According to standard Friedmann-Lemaître-Robertson-Walker (FRW) cosmology, without inflation, one simply postulates 10^{90} elementary particles.[67] This number is derived from simply geometrical quantitative measurements. One of the tasks at hand is explaining how the universe got so big. The exponential expansion of inflation reduces the problem of explaining 10^{90} particles to the problem of explaining 60 or 70 e-foldings of inflation.[68] Inflationary cosmology therefore suggests that, even though the observed universe is incredibly large, it is only an infinitesimal fraction of the entire multiverse.[69]

The Hubble expansion serves as a factor in the initial conditions of the universe. In the 1920's Edwin Hubble was studying the Andromeda nebula. At least since the time of Immanuel Kant, scientists wondered what these distant enormous objects were (galaxies). With further study, Hubble noticed that these galaxies had a *red shift*; the galaxies were appearing redder than they should have and Hubble postulated that these galaxies were moving away from one another. What was being observed was the same thing that the Doppler effect has on sound. The trajectory of an object has an effect on the wavelength of the sound, or in this case, light. If this expansion is extrapolated the equations of motion then (and even now) can only go but so far—

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[67] Alan Guth, "Eternal Inflation and Its Implications," in *The Nature of Nature*, 487.

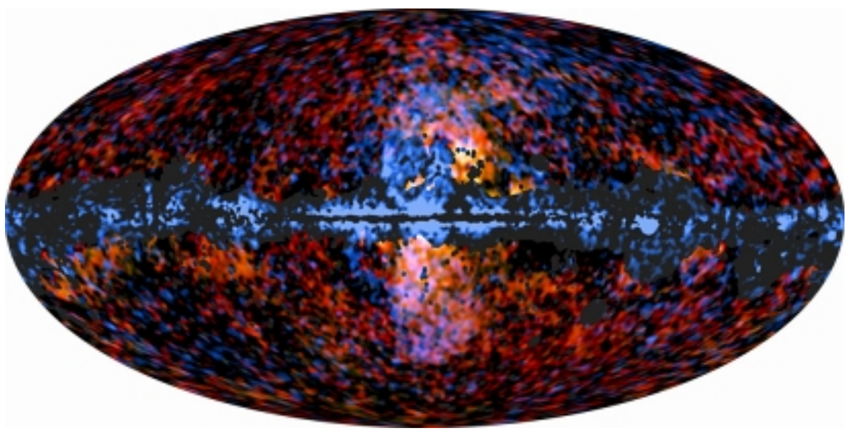
[68] E-foldings are time measurements, which serve as intervals between the exponential growth of a quantity or volume by the factor of *e*.

[69] Ibid.

until the universe comes to a singularity. Inflation actually offers the possibility of explaining how this expansion initially began. The repulsive gravity associated with the false vacuum is what contributes to the explanation. The false vacuum energy density is the exact kind of force needed to propel the universe into a pattern of motion in which any two particles are moving apart wit ha velocity proportional in their separation.[70]

Homogeneity and isotropy refers to the uniformity of the universe. This can be seen in the below image of the Planck Satellite one-year survey results.

Fig. 5.1



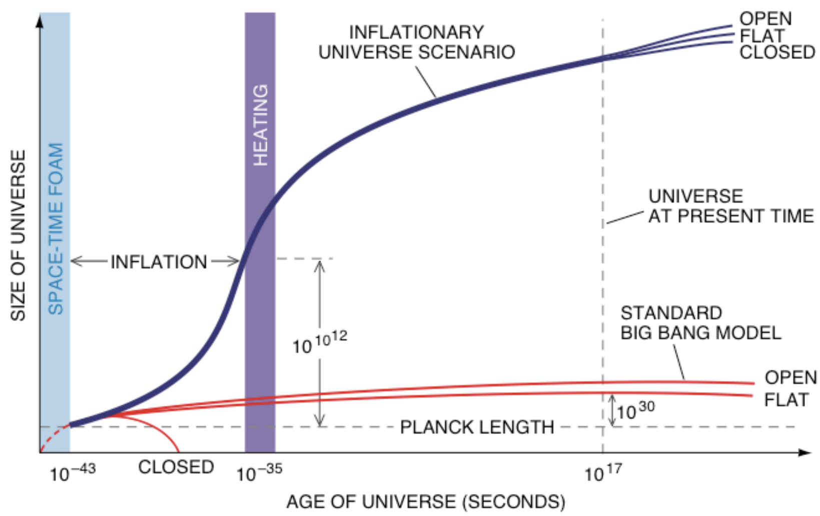
The intensity of the cosmic background radiation is the same in all directions. It is calculated to the incredible precision of one part in 100,000 and possibly even greater precision with developing Planck Survey results.[71] In standard FRW cosmology, the uniformity could be

[70] Ibid., 488.

[71] This all-sky image shows the distribution of the Galactic Haze seen by ESA's Planck mission at microwave frequencies superimposed over the high-energy sky as seen by NASA's Fermi Gamma-ray Space Telescope. The Planck data (shown here in red and yellow) correspond to the Haze emission at frequencies of 30 and 44 GHz, extending from and around the Galactic Centre. The Fermi data (shown here in blue) correspond to observations performed at energies between 10 and 100 GeV and reveal two bubble-shaped, gamma-ray emitting structures extending from the Galactic Centre. This becomes important in next chapter. It has been posited that these bubbles in the data may in fact be the result of an early universe collision with another universe's bubble. ESA/Planck and NASA/DOE/Fermi LAT/Dobler et al./Su et al. http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=50008 (accessed May 6, 2012). P.A.R. Ade, et al, "Planck Early Results. I. The Planck Mission," arXiv: 1101.2022v2 (June 2011).

established so quickly only if information could propagate 100 times the speed of light, a propositions clearly contradicting known physics. However, in inflationary cosmology, the uniformity is easily explained by the creation of uniformity on microscopic scales via normal thermal-equilibrium processes. Inflation then takes over and stretches the regions of uniformity to become large enough to encompass the observed universe.[72]

Fig. 5.2[73]



The flatness problem is related to the precision required for the initial value of Ω, the ratio of the actual mass density to the critical mass density. This occurred when Robert Dicke and P.J.E. Peebles pointed out that at $t = 1$ second after the big bang nucleosynthesis were just beginning, Ω_{tot} (total) must have equaled one to an accuracy of one part in 10^{15}. If this ratio were

N. Aghanim, et al, "Planck Intermediate Results II: Comparison of Sunyaev-Zeldovich Measurements from Planck and from the Arcminute Microkelvin Imager for 11 Galaxy Clusters," arXiv:1204.1318v3 (May 2012). Guth, "Eternal Inflation," 488.

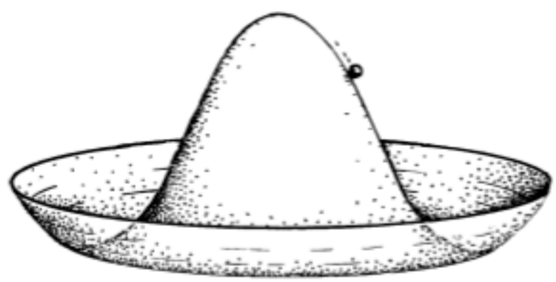
[72] Ibid.

[73] Andrei Linde, "The Self-Reproducing Inflationary Universe: Recent Versions of the Inflation Scenario Describe the Universe as a Self-Generating Fractal That Sprouts Other Inflationary Universe," *Scientific American* (Nov. 1994): 54.

not accurate to this degree the resulting universe would not resemble our own.[74]As depicted in figure 5.2 the evolution of the universe differs between inflation scenarios and FRW scenarios. The standard FRW cosmology does not have an explanation for the Ω value while inflation does.

Magnetic monopoles are extremely massive particles carrying a net magnetic charge, which is a result of predictions made by all the grand unified theories. By combining the grand unified theories with non-inflation scenarios the expected age of the universe is no longer 13.73 billion years old but it becomes about 30,000 years old.[75] Inflation eliminates these monopoles by arranging the parameters so that inflation takes place after or during monopole production, so the monopole density is diluted to a completely negligible level.[76]

Fig. 5.3[77]



These preliminaries for inflation will help understand what exactly inflation accomplishes and what it predicts. Sometime between 1983-1986 Andrei Linde developed and proposed a model of eternal chaotic inflation, for which the energy density, with the initial randomly chosen value of the fields corresponds to a point hill, *contra* a Mexican hat with a bowl shape, then

[74] Alan Guth, *The Inflationary Universe: The Quest for a New Theory of Cosmic Origins* (Reading, MA: Perseus, 1997), 332. R.H. Dicke and P.J.E. Peebles, (1979) in S.H. Hawking and W. Israel, Eds. *General Relativity: An Einstein Centenary Survey* (Cambridge: Cambridge University Press, 1979).

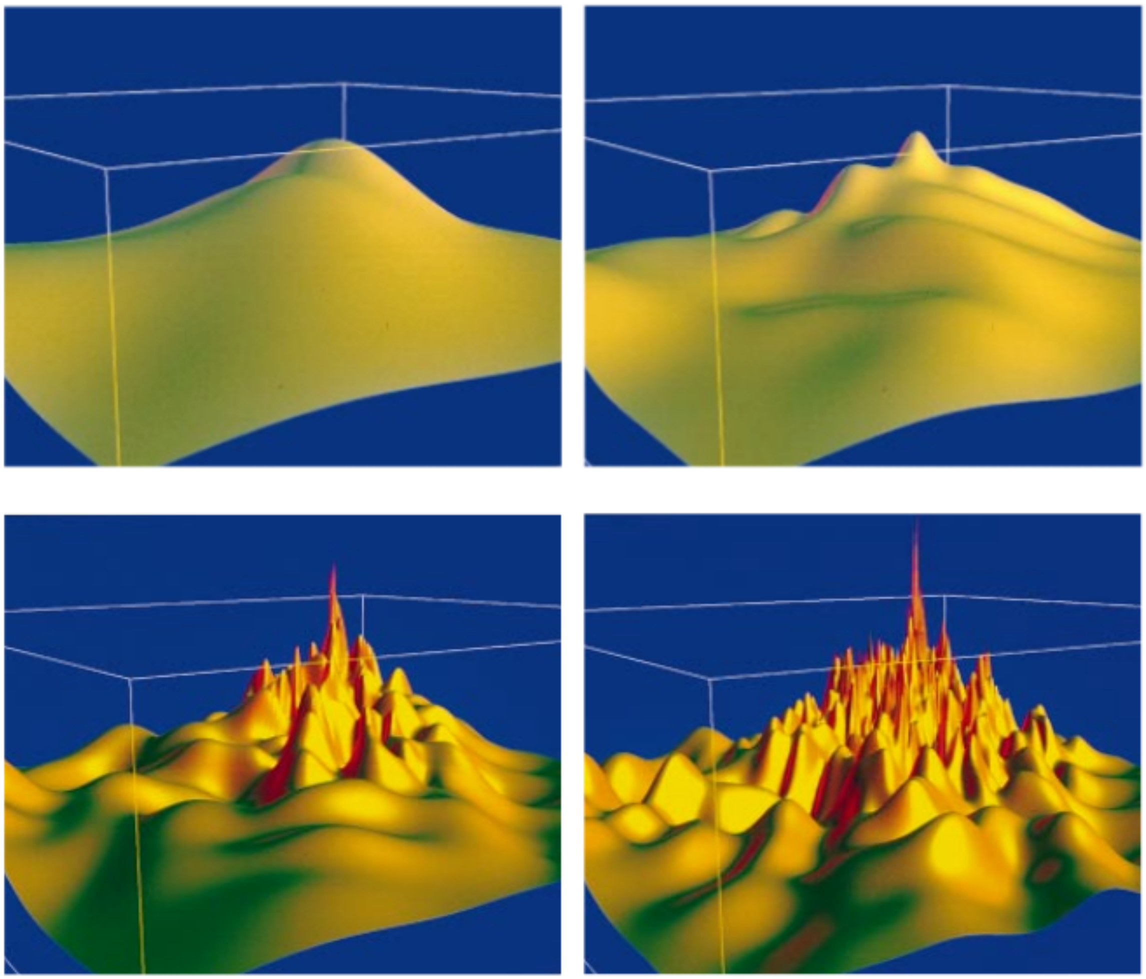
[75] Guth, "Eternal Inflation," 490

[76] Ibid.

[77] Roger Penrose, *The Road to Reality* (New York: Random House, 2004), 737.

sufficient inflation can occur as the fields roll towards the state of minimum energy density.[78] Consider the evolution of the scalar field below:

Fig. 5.4[79]



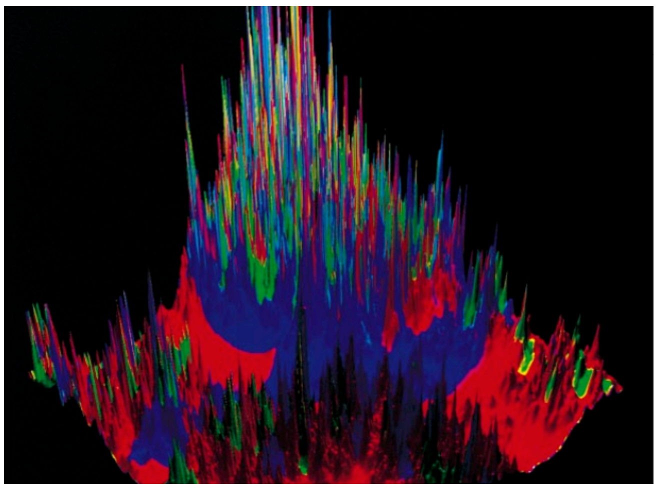
As depicted in figure 5.3 the evolution of the scalar field leads to many inflationary domains as revealed in this computer-generated depiction. In most parts of the universe, the scalar field decreases (the depressions and the valleys). In other places quantum fluctuations cause the scalar field to augment. In those places, represented as peaks, the universe undergoes inflation and rapidly expands, leading to the creation of inflationary regions. Our Hubble volume is in one

[78] Guth, *The Inflationary Universe*, 327.

[79] Linde, "The Self-Reproducing Universe," 50-51.

of the valleys, where space is no longer inflating.[80] Each of these peaks consists in large domains, which have different laws of physics (represented by the different colors in figure 5.5 below).[81] Sharp peaks are big bangs; their heights correspond to the energy density of the universe there. At the top of the peaks, the colors rapidly fluctuate, indicating that the laws of physics there are not yet settled. They become fixed only in the valleys, one of which corresponds to the universe we live in now.[82]

Fig. 5.5[83]



Due to the nature of inflation each valley produces a universe with different values, which is a prediction of quantum cosmology. Inflation is not a monolithic in form (eternal, chaotic, new, string, etc.); however, each model has the basic premise as described above. Not only does inflation have scientific attraction for conforming observations, theory, and data but yields a philosophical satisfaction in attempting to explain away fine-tuning. In the standard

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[80] Ibid.

[81] This would be the same space where the Coleman and De Luccia instanton functions, which allows for vacua decay via bubble nucleation (of a bubble universe). Michael P. Salem, "Bubble Collisions and Measures of the Multiverse." arXiv:1108.0040v2 (Dec. 2011), 2.

[82] Linde, "The Self-Reproducing Universe," 49.

[83] Ibid.

FRW big bang model inflationists see fine-tuning as 'ugly.' The claim is that the need for such fine-tuning of the initial state is removed in the inflationary picture, and this is regarded as a more aesthetically pleasing physical picture.[84] Additionally, if inflation is true then there is not one universe but a multiverse, potentially infinite in number.[85]

IV. String Theory

Just as inflationary cosmology refers to L1M and the L2M string theory refers to L3M and L4M, which encompasses L1M and L2M as well. The spontaneous breakdown of symmetries[86] in the early universe can produce linear discontinuities in fields, known as cosmic strings. Cosmic strings are also common in modern string theories in which the most fundamental reality are astronomically tiny vibrating strings (either closed or open depending on the interpretation of the mathematics).[87] The combination of the string/scalar landscape with eternal inflation has in turn led to a markedly increased interest in anthropic reasoning. In this multiverse scenario life will evolve only in very rare regions where the local laws of physics just happen to have the properties needed for life, giving a simple explanation for why the observed

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[84] Penrose, *The Road to Reality*, 755.

[85] Referring back to chapter two, multiverse scenarios can quantify individual universes as an actual infinite set or finite in number with universes continuously being created adding to the total number—thus potentially infinite.

[86] This refers to the symmetry of particles. For every particle there is a corresponding symmetric particle. Physics has a translational symmetry, which means that the laws and values of physics are the same at every location in the universe. If an observer were to travel from one point to a much farther distant point the observer we see no change in the physics. A broken symmetry introduces change—a non-absolute uniformity. The breaking of symmetries creates complexity in the laws of nature in the outcome of laws. There is a symmetry and uniformity between the strong and weak nuclear forces, which have been unified as electromagnetism by James Clerk Maxwell. A typical example of vital symmetry breaking is that which gives rise to the balance between matter and antimatter in the early universe. However, there is an asymmetry between the quantum and the large (*a la* gravity). String theory is the attempt to unify all of physics. Barrow, *The Constants of Nature*, 282-84.

[87] Edmund J. Copeland, Robert C. Myers, and Joseph Polchinski, "Cosmic F- and D-Strings," Cornell University Library arXiv: hep-th/0312067v5 (May 2004): 1-3.

universe appears to permit the evolutionary conditions for life. It is argued that such anthropic reasoning can give the illusion of intelligent design without the need for any intelligent intervention.[88] There are at least four ways we can understand the different universes described by string landscape.[89]

The first version depicts various universes as simply occupying different regions of space. This is most simply realized in chaotic inflation. Inflation fields do not vanish but different universes are created in different parts of the universe/multiverse.[90] The scalar fields in different inflating patches may take different values, giving rise to different values for various effective coupling constants. The second version describes universes as different eras of time in a single big bang. What appear to be constants might actually depend on scalar fields that change slowly as the universe expands.[91] The third version depicts universes as different regions of spacetime. This can happen if various scalar fields on which the constants of nature depend change in a sequence of first-order phase transitions.[92] In these transitions meta-stable bubbles form within a region of higher vacuum energy and in these bubbles there are bubble that form with a lower vacuum energy.[93] It has been suggested that in this scenario the geometry of the

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[88] Alan Guth, "Eternal Inflation," 495.

[89] This can also be used to compare and contrast with Tegmark's hierarchy. These versions are proposed by Steven Weinberg in "Living in the Multiverse," in *The Nature of Nature,* 553-54.

[90] Renata Kallosh, et al, "Chaotic Inflation and Supersymmetry Breaking" arXiv: 1106.6025v2 (July 2011): 8.

[91] Weinberg, 553.

[92] L.F. Abbott, "A Mechanism for Reducing the Value of the Cosmological Constant," *Physics Letters* B 150 (1985): 427. Weinberg, 553.

[93] Jonathan L. Feng, et al, "Saltatory Relaxation of the Cosmological Constant," *Nuclear Physics* B 602 (2001): 307.

universe is small for anthropic reasons and possibly large enough to be detected.[94] The final version treats the universes as wave functions (a part of quantum mechanical Hilbert space), which lead to superpositions of wave functions in which any coupling constant not constrained by symmetry principles would take any possible value. Stephen Hawking argues that a simple "minisuperspace" model this boundary condition leads to a wave function, which can be interpreted as a superposition of quantum states, which are peaked around a family of classical solutions of the field equations. These solutions are non-singular and represent oscillating universes with a long inflationary period. They could be a good description of the observed universe.[95]

V. Anthropic Reasoning in Multiverse Scenarios

In order to invoke multiverse scenarios as a means of avoiding the problems of fine-tuning it is the hope for the objector to FT that the larger the number of possible values of physical parameters provided by the string landscape, the more string theory legitimates anthropic reasoning as a new basis for physical theories.[96] Not only does this become a physical theory but a metaphysical theory. Roughly speaking, the anthropic argument takes as its starting point the fact that the universe we perceive about us must be of such a nature as will produce and accommodate the existence of the observers who can perceive it.[97]

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[94] Ben Freivogel, et al. "Observational Consequences of a Landscape," *Journal of High Energy Physics* 3 (2006): 39.

[95] Stephen Hawking, "The Quantum State of the Universe," *Nuclear Physics* B 239 (1984): 257. Weinberg, 553.

[96] Weinberg, 548.

[97] Penrose, *The Road to Reality*, 758.

Traditionally there are two forms:[98] the weak (WAP) and the strong (SAP). The WAP is a reflective and happenstantial inquiry: The observed values of all physical and cosmological quantities are not equally probably but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirement that the universe be old enough for it to have already done so.[99] The SAP is much more problematic: rather than considering just one universe we envisage an ensemble of possible universes—among which the fundamental constants of nature vary. Sentient beings must find themselves to be located in a universe where the constants of nature (in addition to the spatiotemporal location) are congenial.[100] There is another anthropic principle Tegmark introduces specifically related to multiverse scenarios—the minimalistic anthropic principle (MAP). Tegmark believes the anthropic principle has generated more heat than light with so many different interpretations. MAP states that when testing fundamental theories with observational data, ignoring selection effects can give incorrect conclusions.[101] My response to MAP will be in Chapter 5 on whether selection effects are sufficient explanations for what we observe.

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[98] There is actually teleological anthropic principle, the Final Anthropic Principle (FAP): Intelligent, information processing must come into existence in the universe, and, once it comes into existence, it will never die out. If scientists and mathematicians could ever have a sense of humor, the polymath Martin Gardner referred to FAP as the Completely Ridiculous Anthropic Principle (CRAP). Martin Gardner, "Wap, Sap, Pap, and Fap," *New York Review of Books* 23 no. 8 (May 8, 1986): 22-25.

[99] John Barrow and Frank Tipler, *The Anthropic Cosmological Principle* (Oxford: Oxford University Press, 1986), 16.

[100] Penrose, *The Road to Reality*, 758-59.

[101] Tegmark, "Parallel Universes," 8.

Fig. 5.6[102]

John Barrow and Frank Tipler have three different interpretations for the SAP: 1) There exists one possible universe designed with the goal of generating and sustaining observers; 2) observers are necessary to bring the universe into being; and 3) An ensemble of other different universes is necessary for the existence of our universe. The ~FT starts with the universe or environment and argues that life evolved to be compatible with the environment (either WAP or SAP). The WAP does not seem to have any explanatory hypothesis over the actual values and existence of the universe we find ourselves in. It is useful for noting whether the laws of physics have changed in our lifetime. Obviously, if it changed then we would not be here to observe it. WAP becomes abused when it is treated as an explanatory hypothesis to account for fine-tuning.

The FT starts with life and looks at all the sufficient and necessary conditions that are required for life to exist. These conditions are considered to be the fine-tuning data. Therefore, the FT will adopt the SAP1 interpretation.

Physicist Victor Stenger advocates the multiverse as an explanatory hypothesis to account for the anthropic principle; thus, adopting SAP3. He offers one possible natural explanation for the anthropic coincidences being that multiple universes exist with different

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[102] Let universe on the left depict the WAP scenario and the universe on the right, amongst alternative universes, depict the SAP. Ibid., 759.

physical constants and laws and our life form evolved in one suitable for us.[103] In the analogy of having a computer with knobs, which determine the value of all the physical parameters if one ever so slightly changes the value of, say, the weak nuclear force life could not exist. Stenger is of the opinion that if one were to completely reconfigure every different value with different physics then that will sufficiently explain the existence of life.[104] This analogy offered by Stenger and SAP3 will be the primary focus in chapter six where I will harmonize these multiverse scenarios with FT and attempt to demonstrate that these scenarios actually increase the explanatory power and scope of FT.

The SETI program (Search for Extra Terrestrial Intelligence) is based on the sole premise that intelligent causation is detectable scientifically. They implement the Drake equation to demonstrate the probability for ETI has a high probability (N).[105]

$$N=N^{*}\times f_p\times n_e\times f_l\times f_i\times f_c\times f_L$$

The problem with the equation is that each f is a number between 0 and 1, the product of the equation will be vastly lower than the total number of suitable stars in the galaxy N^{*}. Many variables are unknown. So, the numbers that are brought in depend profoundly on the assumptions we bring into the problem.

There have been those who argue for the use of a modified Drake equation for multiverse scenarios.[106] The following is the fundamental form of the equation:

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[103] Victor Stenger, *The Fallacy of Fine-Tuning: Why The Universe is Not Designed for Us* (Amherst, NY: Prometheus, 2011), 42.

[104] Victor Stenger, *God: The Failed Hypothesis: How Science Shows That God Does Not Exist* (Amherst, NY: Prometheus, 2008), 137-164.

[105] N^{*} Number of stars in the Milky Way, f_p Number of habitable planets in each system, n_e number of planets that are Earth like, f_l number of planets that emerge from inorganic matter or organic precursors, f_i fraction of those planets on which intelligent beings also evolve, f_c fraction of those planets on which sufficient communications technology arises, f_L fraction of average planet lifetime.

$\{c_{cosmo}\} \oplus \{c_{astro}\} \oplus \{c_{life}\} \oplus \{c_{complex\ life}\}$

Concerning $\{c_{cosmo}\}$, few parameters are: vacuum energy density, matter-antimatter asymmetry, dark matter density, and perturbations for the formation of large-scale structure. To these, one adds the couplings of the four interactions and the masses of quarks and leptons so that hadrons and then nuclei can form after electroweak symmetry breaking. $\{c_{astro}\}$ includes constraints in galactic morphology and stellar ages and types. In order to retain heavy elements, galaxies must have masses above a certain value. Numerical results suggest that galaxies with M ≥ 109M⊙ (M⊙ denotes the mass of a star) are able to retain about ≥ 30% of their heavy elements.[107] $\{c_{life}\}$ includes the planetary and chemical constraints for the existence of life. Of the planets in the habitable zone, only a fraction will have the right preconditions for life: liquid water and the elements C, O, H, N, and the less abundant but no less needed P, S, Fe, Ca, Na, Cl, etc. Apart from water, other simple molecules are also supposed to be present, although the specifics may differ (CH4, CO2, NH3…).[108] $\{c_{complex\ life}\}$ includes planetary constraints that would essentially ensure the continuity of fairly stable environmental conditions thought to be needed for complex, multicellular life to evolve. To begin, terrestrial life's complexity seems to be intrinsically linked to the rise of atmospheric oxygen, courtesy of photosynthetic bluegreen algae. Anoxic environments do not seem very conducive to multicellular life, although there is much we do not know of Earth's biota. However, we do know that complex life is more fragile and requires more

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[106] Let the direct sum symbol, ⊕, denote 'together with.' Marcelo Gleiser, "Drake Equation from the Multiverse: From the String Landscape to Complex Life," arXiv: 1002.1651v1 (Feb. 2010).

[107] Ibid., 3-4.

[108] Ibid., 4.

efficient energy-processing metabolism to be sustained: planetary platforms able to harbor complex life forms must thus satisfy extra requirements.[109]

Notice that each factor is a condition for the one following. For example, $\{c_{life}\}$ must be met in order for $\{c_{complex\ life}\}$. One of the obvious problems with the multiverse equation, like the original Drake equation (which has been changed several times by SETI), is that the values are largely unknown and are leaping guesses. Marcelo Gleiser, the author of the paper, discusses one of the problems in applying a probability equation like this one to a multiverse is that there are several different multiverse scenarios. If the values of the laws of physics vary from universe to universe then there has to be some type of selection effect to account for the variance. In the end, I do not think any probability argument like the Drake equation will be ultimately sufficient. There are too many unknown factors. While each factor is true and a condition for intelligent life, the values are simply unknown. I prefer fine-tuning arguments, which consider the values of the laws of nature and initial conditions only (the Drake equation is not an argument in and of itself, that is important, nor do I think it should be used). My preference is to argue the fine-tuning of the multiverse scenarios and mechanisms involved for the production of the universes (Einstein's field equations, for example) and variance in the values of physics (superstring theory). Environmental factors, like the galactic and stellar habitable zones, merely add more weight to the arguments after the main argument has been established.

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[109] Ibid.

CHAPTER FIVE: COMPARING THE FINE-TUNING HYPOTHESIS WITH THE MULTIVERSE

I. What Does it Explain?

Scientific theories should make predictions. This is a simple consequent to observation. If the theory is based on observed evidence, which is applicable to past observation and present observation than, if true, it should be observed in the future. However, the multiverse hypothesis, if it truly is appropriate to call it a hypothesis, is actually a prediction from a set of scientific theories.[110] In the following sections I will argue that should the multiverse hypothesis be scientific then it would follow that FT is a legitimate scientific inference. This inference cannot be bifurcated from philosophy. The classification of whether or not something is scientific is a philosophical task. I contend that FT is harmonious with the philosophy and methodology behind the historical sciences.

II. Is it a Legitimate Scientific Hypothesis?

In this section I will attempt to make the case that the multiverse hypothesis is to be taken as a serious objection to FT. It is not my intent to make a definitive claim as to whether the multiverse is or is not science; rather, this section will argue that the multiverse should not be considered *ad hoc* conjecture. The multiverse hypothesis certainly has abnormal or weird implications for morality,[111] free will,[112] modality,[113] and theism.[114] The complaint about the

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[110] Tegmark, "The Multiverse Hierarchy," 1.

[111] See Mark Heller, "The Immorality of Modal Realism, Or: How I Learned to Stop Worrying and Let the Children Drown," *Philosophical Studies* 114 (2003). Philip Quin, "God, Moral Perfection and Possible Worlds" in *God: The Contemporary Discussion*, Ed. Frederick Sontag and M. Darrol Bryant (New York: The Rose of Sharon Press, 1982).

[112] Ibid.

multiverse's weirdness is an aesthetic issue rather than a scientific issue. The multiverse does not allow for subjective nostalgic bias towards cozy classical concepts (especially in the L3M and the L4M). As long as there are no *contradictions* weirdness is aesthetic and not a scientific claim. For instance, criticism of the Everett interpretation of quantum mechanics for being "too crazy" falls into this forbidden category.[115]

A theory is distinct from a mere scientific explanation. Scientific explanation requires a causal explanation, which requires a law-governed explanation. Natural law describes but does not explain natural phenomena. Newton's law of universal gravitation described, but did not explain, what caused gravitational attraction. Theories unify empirical regularities and describe the underlying process that accounts for these phenomena. Within theories are axioms, a small set of postulates, which are not proved in the axiom system but assumed to be true.[116]

A scientific theory goes beyond natural laws and scientific explanations in explaining the scientific explanations. A theory refers to a body of explanatory hypotheses for which there is strong support.[117] Theories are a conjunction of axioms (of the laws of nature) and correspondence of rules specified in a formalized ideal language. This ideal language is

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[113] See David Lewis, "Modal Realism at Work" in *Metaphysics* Ed. 8. Eds. Peter van Inwagen and Dean W. Zimmerman (Oxford: Blackwell, 2008).

[114] See Michael J. Almeida, "Theistic Modal Realism?" *Oxford Studies in Philosophy of Religion* 3 (2011). Don Page, "Does God So Love the Multiverse?" arXiv:0801.0246v5 (Jan. 2008).

[115] Max Tegmark, "Is "The Theory of Everything" Merely the Ultimate Ensemble Theory?" arXiv:gr-qc/9704009v2 (Dec. 1998): 28. "The Multiverse Hierarchy," 8-10. Tegmark accuses those who claim that the multiverse is too weird to be true to be stuck in the Aristotelian paradigm—the subjectively perceived local perspective is physical real and a bird's eye perspective of reality is all mathematical semantics that serves as a useful approximation. Tegmark advocates a Platonic paradigm in which the bird perspective [of mathematical structures] is physically real and the subjective local perspective and all the human language we use to describe is merely a useful approximation for describing our subjective perceptions. Ibid., 10.

[116] Rosenberg, 117.

[117] Ibid., 115.

composed of three parts: logical terms, observational terms, and theoretical terms. The logical terms were initially treated as analytic claims (particularly under the hypothetico-deductive model).[118] Observational claims were to be unproblematic, understood as referring to

[118] Tracing the structure of theory back to David Hume, the logical language of a theory was considered to be analytic. In the nineteenth century there was an agreement that Baconian induction was an overly restrictive method, and that the hypothetico-deductive method was superior, given that scientific certainty was being recognized as unattainable and not as certain as it once was thought. Explanations were derived from deduction. Also, the logical connection between these laws is not simply "They work together" since that would be too broad and vague, nor would it necessarily entail "logically implies." A theory cannot be captured by the notion of logical derivation alone. Thomas Nickles, "Demarcation Problem," in *The Philosophy of Science*, Eds. Sahorta Sarkar and Jessica Pfeifer, 190. Rosenberg, 122. Since Humean and logical positivist methodology philosophers have recognized that these strong logical connections are not as strong as they would have considered. The logical connections are merely deriving observable consequences from the set of laws that explain. According to the hypothetico-deductive model, evidence supports the hypotheses that it entails. A hypothetico-deductive argument runs the risk of yielding the absurd result that any observation supports every hypothesis, since any hypotheses is a member of a premise set that entails that observation. This is the idea that theories and hypotheses are confirmed by their observed deductive consequences. Lipton, 2. Ellery Eells, "Confirmation Theory," in *The Philosophy of Science*, Eds. Sahorta Sarkar and Jessica Pfeifer, 147.

This is different from the positive-instance criterion and the satisfaction criterion. For instance, "A is an F and A is a G," which is a case of positive-instance of the hypothesis that all Fs are Gs, is not a deductive consequence of the hypothesis. These criteria have the idea that observations are logically consistent with a hypothesis will confirm the hypothesis. The hypothetico-deductive states that deductive consequences of a hypothesis or theory confirm the hypothesis or theory. Eells, 147. One of the problems with the hypothetico-deductive methodology is that it suffers from the fallacy of affirming the consequent. Philosophers recognized this limitation and accepted the reality that scientific explanations and theories could not be infallible. This led to the development of different inductive and modest abductive models (i.e. I-S model). Nickles, 190. However, one of the inescapable aspects of the hypothetico-deductive model is that, like every theorem, certain terms such as axioms will not be defended by any logical method of reasoning but will be assumed to be true. (Additionally, to call a statement an axiom is not to commit to its truth, but simply to identify its role in a deductive system.) No fallacy is necessarily present in doing so—a large number of theorems are derived from axioms deductively. Also, a statement may be recognized as an axiom in one system but as a theorem in the next. Rosenberg, 190. Thus, the hypothetico-model should not be rejected for its deductive problems since it encompasses many theorems and axioms derived from the same methodology. What makes a theory distinct from laws is that it cannot merely consist of logical relations to one another. There has to be something more to being a theory than merely having an axiomatic structure from which theorems can be derived (i.e. the ideal gas law and the similarity to the quantity theory of money). Rosenberg, 122.

One of the chief components in connecting observational language with theoretical language was the causal structure of underlying processes. The problem is that an underlying causal structure may not provide the degree of illumination and explanation desired. One of the problems was Humean empiricist claims that causation may not be as incorrigible as we may think it is. Rosenberg, 123. Hume never denied causation; he just gave reason to suspect its prima facie appearance or supposed mechanism (or absence of mechanism). Propositional beliefs were based on perception by being derived from sense perceptions. Thus, for the Humean and Baconian empiricist, causation inevitably became habits of the mind rooted in association (or a logical reconstruction of Hume's psychologisitic view.) This does not incorrigible sense-data and later to publicly available physical objects. Correspondence rules were used to connect theoretical language to observational claims.[119] The issue of observation is obviously one of contention. How is it even *possible* to observe the multiverse on any level?

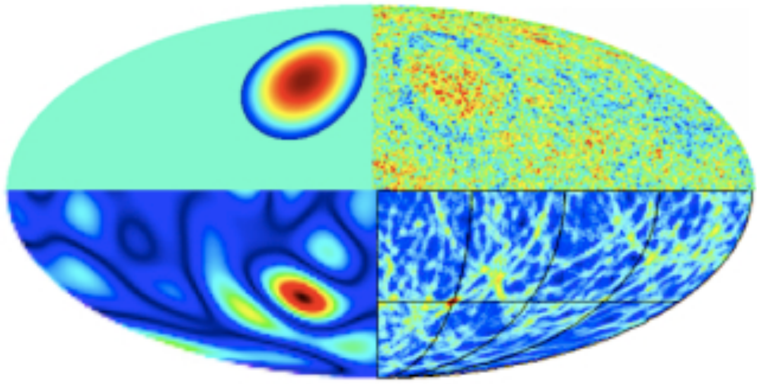
If there were relatively nearby regions of other Hubble volumes, a prediction of inflation, then it would be reasonable to expect early universe collisions between the bubbles. Using the W-Band 94 GHz survey of the WMAP data a specified algorithm was used to detect temperature modulations in the very early universe:

give a sufficient reason for rejecting the correlation between observation language and theoretical language; rather, it is a footnote reminder in this methodology. The hypothetico-deductive view, according to logical empiricists, posited that propositional beliefs are based on sense perception in that they must be tested in terms of their implications regarding sense perceptions. Adherents of the hypothetico-deductive view must posit how hypotheses are obtained and show how those hypotheses are obtained. Dudley Shapere, "Observation," in *The Philosophy of Science*, eds. Sahorta Sarkar and Jessica Pfeifer (New York: Routledge, 2006),524 Theories have a predictive power under this view. Theories are tested by the observational predictions deducible from the system of axioms.

The development of the kinetic theory of gas using Newton's laws of motions as axioms gave an example of how causal structure explains observational data. The approached used was the deductive-nomological method, which later became associated with axiomatic or syntactic approach to scientific theories associated with hypothetico-deductivism. Rosenberg, 125. One of the axioms derived from the Newtonian system was that there were strong grounds for determinism about everything in nature.

[119] Jessica Pfeifer and Sahotra Sarkar, *The Philosophy of Science*, Eds. Jessica Pfeifer and Sahotra Sarkar, xii.

Fig. 6.1[120]



Recent theoretical work[121] has established that bubble collisions produce detectable signals and still be compatible with observed cosmology. These bubbles necessarily collide, upsetting the homogeneity and isotropy of our bubble interior, and possibly leading to detectable signatures in the observable portion of our bubble. This would be a direct experimental test of inflation and the string theory landscape.[122] This data is not confirmatory and can only suggest a L2M, which would also entail a L1M. The current WMAP data is not as precise as desired and the data from upcoming Planck data will be corroborated with this data. Thus, by the criterion of observability the multiverse cannot be ruled out as being unscientific.[123]

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[120] These are signatures of a bubble collision at various stages in the analysis pipeline. A collision (top left) induces a temperature modulation in the CMB temperature map (top right). The "blob" associated with the collision is identified by a large needlet response (bottom left), and the presence of an edge is determined by a large response form the edge detection algorithm (bottom right). (Authors' caption.) Stephen M. Feeney, et al., "First Observational Tests of Eternal Inflation," arXiv: 1012.1995v3 (July 2011): 3.

[121] Anthony Aguirre and Matthew C. Johnson, "A Status Report on the Observability of Cosmic Bubble Collisions," arXiv: 0908.4105v2 (Sep. 2009).

[122] Ibid., 1. Feeney, et al., 1-3.

[123] L3M and L4M will be discussed in the criterion of falsifiability. Remember, not every aspect of a hypothesis, theory, or scientific explanation must have every facet of it meet the requirements of being scientific. Because the L3M and the L4M are specific to Everett's Many Worlds Interpretation the issue of falsifiability is more important than observability. The WMI corresponds to what is observed in particle physics, which is why the multiverse is more of a prediction rather than a theory by itself.

A scientific theory, explanation, or prediction must be put in empirical harms way even though empirical evidence is not a necessary condition for a theory to be scientific. Scientific theories must be supported by facts and empirical evidence is certainly a sufficient condition for science and is preferred depending on the discipline. If the theory is based on facts then it should be able to withstand scrutiny when compared to with relevant facts that could potentially falsify the theory. Contrary to Karl Popper's line of demarcation between science and pseudoscience, a theory absent of evidence is not scientific—it is mere speculation.[124] Popper's model allows for a theory to be scientific prior to and supported evidence. There is no *positive* case for purporting a theory under his model. There can only be a *negative* case to falsify it and as long as it may be potentially falsified it is scientific. Thus, a scientific theory could have not evidence or substantiated facts to provide good reasons for why it may be true.

Lakatos is correct when he states that falsifiability is not the solution to the problem of demarcation in science.[125] Falsifiability is not a necessary condition for a scientific theory because it does not meet it is own requirements. Thus, falsifiability is a sufficient condition for a scientific theory and should be preferred.

Perhaps the best way to determine the falsifiability of the multiverse is to look to Popper's own critiques of Everett's Many Worlds, which concerns L3M and L4M. Popper is actually quite pleased with Everett's threefold contribution to the field of quantum physics. (1) The MWI is completely *objective* in its discussion of quantum mechanics.[126] (2) Everett removes

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[124] See Imre Lakatos, "Science and Pseudoscience" in *Philosophy of Science*, Eds. Martin Curd and J.A. Cover (New York: Norton, 1998), 22-23.

[125] Lakatos, 23.

[126] Everett is trying to avoid the subjectivity involved with interpretations such as the Copenhagen Interpretation. A subjective change in the state function would be the discontinuous change brought about by the observation of a quantity with eigenstates Ψ_1, Ψ_2,…, in which the state of Ψ will be changed to

the need and occasion to distinguish between ‘classical’ physical systems, like the measurement apparatus, and quantum mechanical systems, like elementary particles. All systems are quantum (including the universe as a whole). (3) Everett shows that the collapse of the state vector, something originally thought to be outside of Schrödinger’s theory,[127] can be show to arise

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state ϕ_j with probability $|(\Psi, \phi_j)|$. Everett assumes the universal validity of quantum description. The general validity of pure wave mechanics is assumed without statistical assertions for all physical systems, including observers and measuring apparata. Observation processes are to be described completely by the state function of the composite system, which includes the observer and his object-system, and which at all times obeys the wave equation. (The continuous, deterministic change of a state of the system according to $\frac{\partial \Psi}{\partial t} = U\Psi$, the partial differential of the function over the partial differential of the time being equivalent to $U\Psi$ where U is a linear operator.) Hugh Everett, “The Many Worlds Interpretation,” (Diss., Princeton University, 1956), 1-8. One of the objections raised against MWI is that it incorporates linear theory and does not conform to Max Born’s rule of probability. Casey Blood (“The Many Worlds Interpretation of Quantum Mechanics is Fatally Flawed,” arXiv:1010.4767v2 (Dec. 2010): 1-2) argues that at $U(t)$, the time of a measurement, the observer splits in to different versions of the state, which does not relate to the probability of perception. There is no persevering “I” outside of state vectors that is assigned to a single observer. (The issue of the “persevering ‘I’” will be discussed in later sections.) With MWI there is always a corresponding “I” where each version of the observer is equally valid. Thus, there is a valid version of the observer perceiving each outcome; hence, there are many equally valid “I’s.” Therefore, as Blood argues, Born’s rule cannot hold if the perceptions of all versions of the observer are equally valid (Blood, 3-4).

Born’s rule is $|\Psi(x, t)|^2 \triangle x$, which translates as the absolute value of the wave function, or state, of a particle in region x at time t squared is interpreted as a probability ($\triangle x$ depicts the change in the location/region x—the possible/smaller indexing for the range of location). Kenneth Ford, *The Quantum World* (Cambridge, MA: Harvard University Press, 2004), 204-5. Allday, 225-29. One may know with certainty the probability of the function/state of a particle. Erwin Schrödinger and Born were the first to introduce probability back into natural phenomena. David Wallace argues similarly to Tegmark suggesting a subjective likelihood for probability (David Wallace, “Quantum Probability and Subjective Likelihood: Improving on Deutsch’s Proof of the Probability,” arXiv:quant-ph/0312157v2 (May 2005)). Blood dismisses Wallace’s attempt to reconcile probability (Blood, 2, 7). Wallace, following Saunders (Simon Saunders, “Time, Quantum Mechanics, and Probability,” *Synthese* 114 (1998): 273-404), argues that non-Everettian mechanics have similar problems with probability and should not necessarily be preferred over Everettian probabilities. To dismiss Everett due to the MWI problems of probability would be unreasonable (Wallace, “Quantum Probability,” 6).

[127] Everett maintains that, in general, a composite system cannot be represented by a singular pair of subsystem states, but can be depicted only as a superposition of such pairs of subsystem states. For example, the Schrödinger wave function for a pair of particles $\Psi(x_1, x_2)$, cannot always be written in the form $\Psi = \phi(x_1)\eta(x_2)$, the wave function being equivalent to the state of the two particles. Instead, there is no single state for particle 1 or particle 2 alone, but only the superposition of such cases. Everett, 8.

within the universal [Schrödinger] wave function.[128] Despite his attraction to the interpretation he rejects it based on the falsifiability of the symmetry behind the Schrödinger equation.[129]

Popper rightly places Everett's many worlds on the metaphysical par of, what would be considered as, Augustinian science. It is not the case that the MWI is void of metaphysical import. The Schrödinger equation does not predict which of the possible paths a system will actually choose ($\frac{\partial \Psi}{\partial t} = U\Psi$). Concerning the actual outcome of a system Everett states:

> Throughout all of a sequence of observation processes there is only one physical system representing the observer, yet there is no single unique *state* of the observer (which follows from the representations of interacting systems). Nevertheless, there is a representation in terms of a *superposition*, each element of which contains a definite observer state and a corresponding system state. Thus with each succeeding observation (or interaction), the observer state "branches" into a number of different states. Each branch represents a different outcome of the measurement and the *corresponding* eigenstate for the object-system state. All branches exist simultaneously in the superposition after any given sequence of observations. The "trajectory" of the memory configuration of an observer performing a sequence of measurements is thus not a linear sequence of memory configurations, but a branching tree, with all possible outcomes existing simultaneously in a final superposition with various coefficients in the mathematical model. In any familiar memory device the branching does not continue indefinitely, but must stop at a point limited by the capacity of the memory…All states are equally valid.[130]

The postulate here is the assumption of a naturalistic understanding of personhood, which is clearly a metaphysical import. Human consciousness is treated as a physical system that does not

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[128] Karl Popper, *Quantum Theory and the Schism in Physics*, Ed. W. W. Bartley, III (Totowa, NJ: Rowman and Littlefield, 1956, 1982), 89.

[129] The Schrödinger equation is symmetrical with regard to a reversal of the direction of time whereas MWI is not. Popper argues that a beam of particles traveling through a narrow slit can theoretically test this. Each particle of the scattering beam can be taken as an analogue of one of the world-splits; and the whole beam as an analogue of Everett's reality—the many worlds which are not only many, but also a scattering in a random manner relative to each other. Popper suggests that we then invert the direction of time and when we do we see that many worlds of the past are a random scatter. This scatter is arranged in a manner that when they fuse they become correlated, even though there was no interaction between them before their fusion. This is what Popper believes to be the crux in falsifying Everett. Popper, 93-94.

[130] Hugh Everett, "'Relative State' Formulation of Quantum Mechanics," *Reviews of Modern Physics* 29 no. 3 (1957): 454-462.

collapse the wave function as in the subjective interpretations. The MWI carries the same categorical metaphysical import of persons into the interpretation, as does FT. Recall that FT states that the origin of brand new information is a mind, which assumes that a mind bears properties of personhood.[131] Though the metaphysical conclusions of a person, or mental states, are *different*, with Everett's being purely physical and FT being non-physical, there is the common metaphysical category of personhood built in. If the MWI is to be considered scientific then the FT cannot be dismissed as being non-scientific due to any type of metaphysical import since both MWI and FT share the same metaphysical import.

Agent causation is entirely consistent with the scientific method. For example: The FT inference begins with the *observation* that [intelligent] agents produce complex[132] specified [or more than mere Shannon] information. The *hypothesis* would follow with predictions of FT. For *experiments*, one would one need to test whether scientific data has complex specified information. The *conclusion* may follow as: Because X exhibits high levels of complex specified information, a quality known to be a product of intelligence, therefore, FT.

In the following sections I will apply the scientific standards and the principle of falsifiability to the two competing hypotheses. It is my contention that FT and ~FT are both falsifiable. Because the competing hypotheses are falsifiable it should be possible, theoretically, to test them. However, falsifiability does not determine the truth of an explanation; rather, it augments the robustness of the explanation. This allows for a critical examination of the two

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[131] Defining a person can be difficult but the only property of personhood needed for FT is that this person, or mind, is capable of being the origin of brand new information—a mental faculty.

[132] By 'complex' I am referring to Kolmogorov complexity, which states that the complexity *K* is a measure of the descriptive complexity of an object. It is related to, but different from, computational complexity, which measures the time or space required for a computation. Thomas M. Cover and Joy A. Thomas, *Elements of Information Theory* Ed. 2 (Hoboken, NJ: Wiley-Interscience, 2006), 12, 466-75.

competing hypotheses and provides a method for how either hypothesis may be affirmed or denied.

A. The Falsifiability of the Fine-Tuning Hypothesis

When a new discovery or hypothesis is made, philosophers and scientists must work backwards to construct hypotheses consistent with that discovery, and then go on to deduce other consequences that can be experimentally tested. If any of those hypotheses turn out to be false it must be abandoned or modified. Thus, the emphasis on a scientific theory should be falsification and not verification.[133] In order to avoid *ad hoc* conjecture in explaining the data FT must be falsifiable. The main premise of FT is that the mechanisms required for multiverse scenarios and the origin of information can have antecedent material causes. The evidences for FT will be discussed in the following sections. If one is to falsify FT it must be demonstrated that the four mechanisms that require the multiverse to function can be explained by the multiverse selection effect. That is, the evidence set forth in section IV must be explainable in terms of the multiverse acting on itself to bring about those mechanisms. Secondly, the origin of information in the multiverse (i.e. to set the values of the mechanisms and information in general) must have a sufficient material explanation for its origin. Finally, it must be demonstrated that these two conditions are more probable than a mind acting on the conditions. If the multiverse can explain its own mechanisms, the values for the mechanisms, and if this is more probable than a mind acting on these mechanisms to determine their values then there may be good reason to reject FT as being falsified.

B. The Falsifiability of the Non-Fine-Tuning Hypothesis

The two competing hypotheses rise and fall on the same crux. One of the problems with falsifying ~FT is that whatever falsifier may be presented it could always be attributed to this

[133] Paul Davies, *The Mind of God* (New York: Simon & Schuster, 1992), 28.

idea of cosmic Darwinism, the evolution of the multiverse itself. Paul Davies criticizes the multiverse because he believes it could never be falsified simply because many worlds can be used to explain anything. Science would become redundant and the regularities of nature would need no further investigation, because they could simply be explained as a selection effect, need to keep us alive and observing.[134]

The danger of accepting an effectively unfalsifiable hypothesis is that science has no way to determine if the belief corresponds to reality. Historically, the scientific community has affirmed several instances of things that were in fact not true—for example, the universal ether.[135] If it is the case that anything that resembles FT can be attributed to or assimilated by ~FT makes ~FT incredibly difficult to falsify—if not impossible. If ~FT is unfalsifiable it can never rest in empirical harm's way. Here, the key point that needs to be falsifiable is the explanation of the multiverse (FT or ~FT) and not the multiverse itself.

III. The Gambler's Fallacy

Suppose that by postulating a greater number of chances a LPU will be selected we may then increase the probability that LPU is not improbable. Instead, it becomes probable or even necessary. The nineteenth century Russian mathematician P. L. Chebyshev developed the following rule (Chebyshev's Theorem):

> **The probability that a random variable will take on a value within *k* standard deviations of the mean is at least $\frac{1}{36}$, where *k* can be any positive number.**[136]

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[134] Davies, *The Mind of God*, 190.

[135] Michael Behe, "The Intelligent Design Hypothesis" in *God and Design*, Ed. Neil Manson (New York: Routledge, 2003), 289.

[136] Where the standard deviation is a measure of the expected chance fluctuations of a random variable, say the nomic behavior as a result of the multiverse selection effect. John E. Freund, *Introduction to Probability* (New York: Dover, 1973), 211.

When this theorem is applied to random variables having binomial distributions[137] it leads to the Law of Large Numbers:

> **If a random variable has the binomial distribution, the probability is at least** $1-\frac{1}{k^2}$ **that the proportion of successes (LPUs) in *n* trials will differ from *p* by less than** $k\bullet\sqrt{\frac{p(1-p)}{n}}$**. When *n* is sufficiently large, we can be virtually certain that the proportion of successes will be very close to the probability of *p* of success for each trial.**[138]

Suppose I am concerned about the possibility that after rolling a pair of dice 14,000 times the observed proportion of 12's may still differ from the probability of actually rolling a 12, which is $\frac{1}{36}$, by 0.01 or more.[139] To find the probability that the proportion of 12's will differ from $\frac{1}{36}$ by less than 0.01, 0.01 must first equal to $k\bullet\sqrt{\frac{p(1-p)}{n}}$ with n = 14,000 and $p = \frac{1}{36}$, and solve for k. Thus,

$$0.01 = k\bullet\sqrt{\frac{\frac{1}{36}\bullet\frac{35}{36}}{14,000}}$$

giving k = 7.2, and the probability is at least $1-\frac{1}{(7.2)^2}=0.98$ that after 14,000 rolls of a pair of balanced deiced the observed proportion of twelves will differ from $\frac{1}{36}$ by less than 0.01. The

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[137] Whenever the assumptions of independent trials and a constant probability from trial to trial can be applied, the probability function for the number of successes is the binomial probability function or the binomial distribution. Freund, 177.

[138] Ibid., 213-14.

[139] This is Freund's example, 214-15.

probability is at most 1-0.98 = 0.02 that the observed proportion of twelves will differ from $\frac{1}{36}$ by 0.01 or more.[140]

Now, perhaps I can provide a simpler example in applying the Law of Large Numbers to multiverse scenarios. Precise, or exact, calculations cannot be made (or at least that's not the present task here) due to unknown variable is the set of *possibilia*. Suppose we take a sample observation of a universe within the multiverse *u*. Now, suppose I run an experiment with *u* depicting the number of trials *n*. Then I divide the trials by *n* to get the sample mean, $\bar{u}_n$, depicted below:

$$\bar{u}_n = \frac{u_1 + u_2 + u_3 ... u_n}{n}$$

The sample mean will approach the expected value, $\bar{u}_n = E(u)$, with the expected value being whatever meets the conditions for LPU (this is what would be expected given the anthropic principles). Or, my sample mean will approach my population mean for $n \to \infty$. In other words, the more universes there are the greater chances of meeting our expected value, $E(u)$, being LPU.

The problem with appealing to multiverse scenarios as the best probabilistic explanation for the likelihood of our universe being a LPU is that this rule of probability only applies to situations that can be repeated.[141] The role probability serves in this argument does not favor the ~FT in multiverse scenarios. If the fine-tuning objector argues that the odds of having a finely tuned universe, which harbors life, increases given the vast number of universes there is bound to be one with the values we have. This is an abuse of probability and commits the gambler's fallacy. This claim assumes a general disjunction rule of probability, that of the Law of Large

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[140] Ibid.

[141] Ibid., 215.

Numbers. For example, this rule of probability suggests that the probability of drawing a king from a deck of cards increases when each card drawn is not replaced. If the deck has all the cards it is supposed to have the probability of *eventually* drawing a king is 1. The multiverse is like the restricted or general conjunction rule of probability. By simply increasing the number of possibilities does not increase the probability of selection. For example, say you randomly draw a card from the deck and you want the king of spades. The odds of you drawing a king of spades are 1/52. Say you draw the three of hearts. When you replace the card and draw another card from random the odds of you getting the king of spades is not increased by the first selection.

IV. The Fine-Tuning of the Multiverse Mechanisms

Single universe scenarios require the fine-tuning of the laws of nature, the fundamental constants, and the initial conditions of the big bang in order for life to exist. The list of necessary parameters is quite extensive. However, the most common reaction to the fine-tuning argument is to appeal to 1 of 4 different types of multiverse scenarios that suggest our Hubble volume is on amongst countless others with these other universes having different physics. To illustrate fine-tuning as a selection effect Tegmark uses the example of the sun.

> [T]he mass of a star determines its luminosity, and using basic physics, one can compute that life was we know it on Earth is possible only if the sun's mass falls into a narrow range between 1.6×10^{30}kg and 2.4×10^{30}kg. Otherwise Earth's climate would be colder than that of present-day Mars or hotter than that of present-day Venus. The measured solar mass is $M \sim 2.0 \times 10^{30}$kg. At first glance, this apparent coincidence of the habitable and observed mass values appears to be a wild stroke of luck. Stellar masses run from 10^{29} to 10^{32}kg, so if the sun acquired its mass at random, it had only a small chance of falling into the habitable range. But…one can explain this apparent coincidence by postulating an ensemble [of planetary systems] and a selection effect (the fact that we find ourselves living on a habitable planet.)[142]

[142] Tegmark, "The Multiverse Hierarchy," 9.

Tegmark's example is describing a case of local fine-tuning (or coincidence) but applies on the universe/multiverse level as well.[143]

However, these multiverse scenarios require just as much of an explanation for the evidence as a single universe. The inflationary/superstring multiverse generator can only produce life-sustaining universes because it has the following four components/mechanisms:

1) A mechanism to supply the energy needed form the bubble universes.
2) A mechanism to form the bubbles.
3) A mechanism to convert the energy of the inflation field to the normal mass/energy we find in our universe.
4) A mechanism that allows enough variation in the constants of physics among universes (one of the predictions of quantum cosmology is random constants).[144]

The first mechanism needed to supply the energy to form the bubble universes is the fine-tuning of the inflation field. Our early universe underwent a rapid inflation causing our space's temperature to decrease and cool to allow for the present structures. The current measurements indicate that dark energy and dark matter dominate our present universe with $\Omega_{DE} \cong 0.73$ and $\Omega_{DM} \cong 0.27$. Inflation sets up the initial energy required to produce these dominant forces/structures. If inflation is not complete or efficient then the remaining energy density within the bubble must be fine-tuned to give the correct value distribution.[145] Attempts to circumvent fine-tuning concerning the inflation field have focused primarily on *describing* what occurs posterior to the moment of bubble inflation.[146] These effects can be explained by the multiverse selection effect but the energy of the inflation field that is converted into "normal" mass-energy, which gives rise to the standard FRW Big Bang universe we observe, cannot be

[143] Ibid., Tegmark, "Parallel Universes," arXiv:astro-ph/0302131v1 (Feb. 2003): 5-8.

[144] Collins, "The Teleological Argument," 262-65.

[145] A. de la Macorra, "Dark Matter from the Inflation Field," arXiv:1201.6302v1 (Jan. 2012): 1.

[146] Ibid., Boris E. Meierovich, "To the Theory of the Universe Evolution," arXiv:1201.2562v1 (Jan. 2012).

explained by the selection effect since it is the inflation field energy is physically prior any fine-tuning or physical parameters within the bubble.[147]

The second fine-tuning mechanism is that which forms the bubbles—Einstein's field equations + the inflation field. Einstein's field equation generally appears as:

$$R_{ik} - \frac{1}{2} g_{ik} R + \Lambda g_{ik} = T_{ik}$$

T_{ik} is the stress-energy tensor, g_{ik} is the g-function, R is the scalar curvature, R_{ik} is the Ricci tensor derived from the Riemann curvature tensor by the algebraic operation of contraction, and the cosmological constant Λ.[148] Originally, Einstein had Λ on the left hand side of the equation describing the geometry of the universe. Upon receiving corrected mathematics from Georges Lemaître and the observational evidence from Edwin Hubble Einstein could no longer use Λ to describe a static universe. But one cannot simply remove the constant from the equation. When it is moved from the left to the right side it no longer describes the geometric structure of the universe but rather the energy-momentum.

The inflation field that gives empty space a positive energy density is needed to achieve mechanisms 1-2. Without either factor, there would neither be regions of space that inflate nor would those regions have the mass-energy necessary for a universe to exist. If, for example, the universe obeyed Newton's theory of gravity instead of Einstein's, the vacuum energy of the inflation field would at best simply create gravitational attraction causing space to contract, not to expand.[149]

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[147] Collins, "The Teleological Argument," 262-63.

[148] Lawrence Sklar, *Space, Time, and Spacetime* (Berkeley, CA: University of California Press, 1974), 75.

[149] Collins, "The Teleological Argument," 264.

The third mechanism that cannot be explained by the multiverse selection effect is the conversion of the energy of the inflation field to the normal mass/energy we find in our universe—Einstein's $E=mc^2$ + the coupling of the inflation field and the matter fields. In order to set Einstein's work in proper perspective, in 1865 James Clerk Maxwell had unified electricity and magnetism by developing his equations of electromagnetism.[150] It was soon realized that these equations supported wave-like solutions in a region free of electrical charges or currents, otherwise known as vacuums.[151] Later experiments identified light as having electromagnetic properties and Maxwell's equations predicted that light waves should propagate at a finite speed c (~ 300,000 km/s). With his Newtonian ideas of absolute space and time firmly entrenched, most physicist thought that this speed was correct only *in one special frame*, absolute rest, and it was thought that electromagnetic waves were supported by an unseen medium called the *ether*, which is at rest in this frame.[152]

Einstein noticed how the Doppler effect could be applied to electromagnetism.[153] His rather brief paper on the relation between the energy and the mass of an object gave rise to his famous equation $E=mc^2$.[154] This meant that mass energy is proportional to mass. Twice as

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[150] At this time in 1905 Einstein published a series of articles. These articles included a parallel of Max Planck's work on black body radiation, his PhD thesis which showed how to calculate the size of molecules and work out the number of molecules in a given mass of material based on their motion, an article on Robert Brown's motion (1827), his article on relativity replacing Newton's laws, and his article on the equivalence of mass and energy. These five works are referred to as Einstein's *annus mirabilis*. Jonathan Allday, *Quantum Reality: Theory and Philosophy* (Boca Raton, FL: CRC Press, 2009), 273.

[151] Vasant Natarajan and Dipitman Sen, "The Special Theory of Relativity," *Resonance* (Apr. 2005): 32.

[152] Ibid., 32 -33.

[153] $v'/v = 1 \pm v/c$ Depending on the relative direction of the light waves and the frame of the observer (v signifies measured velocity).

[154] It will be interesting to see how Einstein applies his *invariance* in his work. His argument developed as follows. Let an object in a rest frame simultaneously emit two light waves with the same

much mass means twice as much mass energy, and no mass means zero mass energy. The square of the speed of light is called the constant of proportionality. It does the job of converting from the unit in which mass is expressed to the unit in which energy is expressed.[155] With this, Einstein's Special Theory of Relativity was born.

The fourth mechanism is what allows enough variation in the constants of physics among universes. After all, one of the predictions of quantum cosmology is random constants. Any given finite region is replicated throughout infinite space, which in turn requires a re-appraisal of quantum probabilities. The matter distribution in space is modeled as evolving from some random initial conditions.[156]

Although some of the laws of physics can vary from universe to universe in M-theory, these fundamental laws and principles underlie M-theory and therefore cannot be explained as a multiverse selection effect. Further, since the variation among universes would consist of variation of the masses, and types of particles and the form of the forces between them, complex

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energy $E/2$ in opposite directions (now having equal but opposite momenta), the object remains at rest, but its energy decreases by E. By the Doppler effect, in another frame, which is moving at the velocity v in one of those directions, the object will appear to lose energy equal to $\frac{E}{2}\sqrt{\frac{1-v/c}{1+v/c}}+\frac{E}{2}\sqrt{\frac{1+v/c}{1-v/c}}=\frac{E}{\sqrt{1-v^2/c^2}}$. The difference in energy loss as viewed from the two frames must therefore appear as a difference in kinetic energy seen by the second observing frame. Hence, if v/c is very small, in the second frame (the one in motion) the object loses an amount of kinetic energy given by $\frac{E}{\sqrt{1-v^2/c^2}}-E\simeq\frac{1}{2}\times\frac{E}{c^2}\times v^2$. Since the kinetic energy of an object with mass M moving with speed v is given by $(1/2)Mv^2$ (for $v/c\ll 1$), this means that the object has lost an amount of mass given by E/c^2. In other words, a loss of energy of E is equivalent to the loss in mass of E/c^2. This implies equivalence between the mass and energy content of any object. It turns out that for a particle of mass M, this quantity is equal to M^2c^2. After implementing the Lorentz invariant (and if the frame in which the particle has zero momentum), then the equation $E=mc^2$ is recovered. Ibid., 41-42.

155 Kenneth William Ford, *The Quantum World: Quantum Physics for Everyone* (Cambridge, MA: Harvard University Press, 2004), 20.

156 This is still applicable in L1M – L4M. Alex Vilenkin, *Many Worlds in One* (New York: Hill and Wang, 2006), 151. Anthony Aguirre and Max Tegmark, "Born in an Infinite Universe: A Cosmological Interpretation of Quantum Mechanics." arXiv:1008.1066v2 (Jun. 2012): 2.

structures would almost certainly not resemble the energy and matter structures we observe in our universe. Thus, the said fundamental laws seems necessary for there to be life in any of the many universes, not merely in a universe with our specific types of particles and forces.[157] What is more is that these four mechanisms are not independent from one another. The fine-tuning of M-theory or superstring theory itself must be fine-tuned in order to have the other three mechanisms to function and bring about any functioning universe or LPU. Appealing to the MAP becomes moot due to the information and values in the mechanisms that drive multiverse selection effects.[158]

V. The Negative Case Against the Non-Fine-Tuning Hypothesis

For a good argument to withstand internal scrutiny there should be good reasons for why that conclusion should be affirmed. That's the place of the positive argument that I have just presented. What makes an argument even more robust is it is ability to critique the other competing hypotheses allowing good reasons to reject the alternate explanations. The positive case for FT is the role of information and that brand new information can only be the result of an

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[157] Collins, "The Teleological Argument," 264-65.

[158] Tegmark does not use MAP and selection effects to rule out everything. It cannot rule out chaotic inflation by the fact that we find ourselves living in the miniscule fraction of space where inflation has ended, since the inflating part is uninhabitable to us. As pointed out by Ludwig Boltzmann, if the universe were in a classical thermal equilibrium (heat death), thermal fluctuations could still make atoms assemble at random to briefly create a self-aware observer (a Boltzmann brain) like us every once in a blue moon, so the fact that we exist right now does not rule out the heat death cosmological model. Tegmark, "Parallel Universes," 8. So, what should we do with Boltzmann brains? Roger Penrose has calculated that if there were a brain in a member in a set of world ensembles the patch of order being observed should be no larger than our solar system amongst the higher entropy. Penrose argues that given the low entropy we find in our early universe it must be fine-tuned to 1 part in $10^{10^{123}}$ (calculations derived from black-hole entropy and mass in the particular region). The amount of space needed for sentient existence is "absurdly" cheaper. In fact, life on earth certainly does not need the CMB radiation or even evolution. Penrose estimates that the entire solar system, including its living inhabitants, could be created from the random collision of particles and radiation with a probability of one part in $10^{10^{60}}$ (or even lower). This figure is "utter chicken feed" by comparison with the $10^{10^{123}}$ needed for the big bang to be in its observed uniform configuration. Penrose, 729-30, 762-65. Well, the mere possibility of an observing brain popping into existence from the high entropy states creating the low entropy order is trivial compared to FT.

antecedent mind. The negative case for FT is that the competing explanations lack the explanatory power and scope since the scenarios required in ~FT are either incredibly improbable[159] or lack logical necessitation.[160]

Robin Collins' postulates a theistic approach in accounting for nomic behavior. The theistic view states that the fundamental regularities in the world are explained by the creative and sustaining power of God: God either sustains these regularities directly, or God has created the sort of fundamental powers or necessities in nature that underlie these fundamental

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[159] Max Tegmark attempts to reconcile the deterministic nature of the multiverse with probability calculations. Let *X* denote what a certain self-aware substructure (SAS, a subject, or, for example, a human being). To be able to predict *X* there must be three known variables:

1) Which mathematical structure the SAS is part of
2) Which of the many SASs is this structure is this one
3) Which instant (according to the time perception of the SAS) we are considering.

However, the probability that Tegmark is concerned with here is an epistemic probability for the knowing subject—the SAS. To calculate the subjective prediction of *X* these factors must be known and indexed. Tegmark, "Ultimate Ensemble," 10-11.

[160] On Max Tegmark's website he has a frequently asked questions section. On June 9, 2003, Tegmark received the following question from Ernesto Viarengo:

> Is it in your opinion possible to imagine a "scientific theology", based on the assumption that in an infinite universe all is possible and even necessary, also the evolution of some intelligent life until a level that we usually consider typical of God?

Tegmark responds with a curious answer.

> An interesting question. I certainly believe the laws of physics in our universe allow life forms way more intelligent than us, so I'd expect that they have evolved (or been built) somewhere else, even at Level I. I think many people wouldn't be happy to call them "God", though, since they would be outside of our cosmic horizon and thus completely unable to have any effect on us, however smart they are (assuming there are no spacetime wormholes). However, perhaps they can create their own "universe", for instance by simulating it, playing God to its inhabitants in a more traditional sense. And perhaps we ourselves live in such a created/simulated universe...

Tegmark appears to be taking a semi-naturalistic approach in explaining the creation and values of particular universes. However, this explanation meets the basic elements of Aristotle's cosmological argument for an unmoved mover. Though Tegmark affirms MM he cannot deny this theistic explanation either. Max Tegmark, "The Universe of Max Tegmark," http://space.mit.edu/home/tegmark/crazy.html (accessed Jan. 24, 2013).

regularities. This is the view undergirding the philosophies of Galileo and Kepler calling God the "great geometer."[161] However, FT is much more modest than Collins' theistic approach. What may be used instead of God is a fine-tuner absent of divine attributes or properties normally associated with the concept of God. Does this suffer an exhausting death of equivocation? I think not. Using a fine-tuner as an inferential entity does not carry the metaphysical, theological, or religious import as Collins' approach does.[162]

The, RT, NT, and the MM are explanatorily empty in the end from a ~FT perspective. RT inevitably becomes a probabilistic expression of universe locales functioning according to its nomic niche in the multiverse. NT certainly explains nomic behavior and should categorically encompass MM. Recall Everett's postulate for the outcome of a state of particles. All outcomes are actualized. Tegmark's postulate, akin to Everett's, is that all structures that exist mathematically also exist physically,[163] which amounts to a picturesque model of Platonism. Since Tegmark is equivocating physical existence, which categorically encompasses nomic behavior, then nomic behavior becomes just as necessary as Platonic objects. This leads to the

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[161] Robin Collins, "God and the Laws of Nature," *Philo 1*2 no. 2 (2009): 1, 16. (Preprint). There is a value-based metaphysical import associated with this view but it I am disinterested in that aspect of the explanation. This is not entirely *ad hoc* given the nature of God; that is, if God is a perfectly free, omniscience, and omnipotent being. Ibid., 18. This is by no means an argument for the existence of God but if God does exist then the laws of nature would be regularities in God's function in nature. The theistic view can encompass any of the three theories: NT, RT, or the MM. The NT makes sense given divine simplicity. If God is simple then transworld simplicity is true, which means God's interaction transworld is identical and flows necessarily from him. RT is consistent with the divine *sensorium* in the laws of nature and not a Kantian categorical projection. The regular course of divine sustainment, regularity, allows for discovery and free invention. The premises or predicates are not fixed necessarily and the conclusions are drawn out of these regularities in a way that could be described as an exegesis of nature.

[162] These imports may be the ontology of God, which convolutes the metaphysical import in needing to delimit which properties of God have any role. The theological and religious imports have to do with identifying who God is. Revealed doctrine having implications for how God would function or act according to his revealed nature. It would be very easy to read these imports back into the argument by retrospection and constructing an argument in a question-begging manner.

[163] Tegmark, "Ultimate Ensemble," 1.

task of probability calculations in multiverse scenarios, which will be examined in the succeeding sections.

VI. The Positive Case for the Fine-Tuning Hypothesis

Max Tegmark has argued that the universe/multiverse contains little to no information. It has on the whole no structure. He suggests that most of this information is merely apparent, as seen from our subjective viewpoints, and that the algorithmic information content of the universe as a whole is close to zero. The appearance of information is "just a figment of your imagination" and that continuum physics can be maintained without involving infinite quantities of information.[164] To argue for the appearance of vast quantities of information in the universe Tegmark makes his argument with the following premises:[165]

1) The wave function of the universe shortly after the big bang had some quite simple form, which can be described with very little algorithmic information.
2) By Heisenberg uncertainty principle, this initial state involved micro-superpositions, microscopic quantum fluctuations in the various fields.
3) The ensuing time-evolution involved non-linear elements that exhibit chaotic behavior (such as the well-known gravitational instability that is held responsible for the formation of cosmic large-scale structure), which amplified these micro-superpositions into macro-superpositions.
4) In the no collapse version of quantum mechanics, the current wave function of the universe is thus a superposition of a large number of states that are macroscopically extremely different (Earth forms here, Earth forms one meter [*sic*] further north, etc).
5) Since macroscopic objects inevitably interact with their surroundings, the well-known effects of decoherence will prevent self-aware subsets of the universe (such as us) from perceiving such macro-superpositions.
6) The net result is that although the wave function of the universe contains almost no algorithmic information (we can specify it by simply giving the initial wave function and the Hamiltonian), and will retain for instance translational and rotational symmetry from the initial data, we will experience an asymmetric universe that appears extremely complex.

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[164] Max Tegmark, "Does the Universe In Fact Contain Almost No Information?" *Foundations of Physics Letters* 9 no. 1 (1996): 25-26.

[165] Ibid., 26-27.

The enormous discrepancy between apparent and actual information content would have been caused by interplay of several well-know effects:[166]

7) Non-linear dynamics evolved quantum states that were initially only microscopically different into quantum states that were macroscopically different.
8) Well-known decoherence effects ensured that only macroscopically "classical" states could be perceived by self-aware subsets of the universe (such as us), so for all practical purposes, the wavefunction of the universe is in a superposition of such states.
9) Although the total wavefunction still contains as little algorithmic information as it did in the beginning (assuming that the laws of physics that govern its time evolution are known), any one element of this superposition (which is all that we can subjectively experience, because of decoherence) will displace the enormous complexity brought about by the chaotic linear evolution.

(1) – (3) describes the evolution of the universal wavefunction with (4) – (8) describing the role of decoherence, or the loss of information. Decoherence is a loss of coherence between the angles of components in a superposition and a loss of information due to environment, which gives the appearance of a wave function collapse. A wave function collapse occurs when an observer determines the outcome of a quantum state. An observer can be a conscious observer or even the interaction of particles. Instead of a determinate state, decoherence is akin to pulling one string out from an entire knot of strings. (9) describes the remaining algorithmic information according to the perception of the knowing subject, which displaces enormous complexity. This chaos is what breaks the symmetry of macro-superpositions and maintains the micro-superpositions (because of decoherence).

Tegmark is not quite clear by what he means by "information." He does refer to it as a relay of content, which may or may not be complex. There must be distinctions in how we use the word "information" and how it is used in cosmological parameters. In the following section I will make the necessary distinctions in defining information and how it is role in cosmology

[166] Tegmark, "No Information," 37.

requires an explanation—FT. This will be the task in the succeeding sections—what will be the best explanation for the origin of information?

A. Not Mere Shannon Information

In the 1940's, Claude Shannon at Bell Laboratories developed a mathematical theory of information. The information-carrying capacity of a sequence of a specific length can then be calculated using the expression I=-$\log_2 p$.[167] When this formula is applied to genetic sequence probability formulas the information being conveyed is *more* than mere Shannon information. The word *information* in this theory is used in a special mathematical sense that must not be confused with its ordinary usage. In particular, information must not be confused with meaning.[168]

Since the late 1950's, biologists have equated the "*precise* determination of sequence" with the property "specificity" or "specification." Biologists have defined specificity tacitly as "necessary to achieving or maintaining function." They have determined that DNA base sequences are specified, not by applying information theory, but my making experimental assessments of the function of those sequences within the overall apparatus of gene expression.[169] The same application of specificity would be applied to complexity. Given the complexity of the components need for and to sustain life, the complexity is that which maintains function, a specified complexity.[170]

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[167] This equated the amount of information transmitted with the amount of uncertainty reduced or eliminated by a series of symbols or characters. Claude Shannon, "A Mathematical Theory of Communication," *Bell System Technical Journal* 27 (1948): 379-423, 623-656.

[168] Claude Shannon, W. Weaver, *The Mathematical Theory of Communication* (Champaign, IL: University of Illinois Press, 1998), 8.

[169] Meyer, "Theory of Intelligent Design."

The ultimate ensemble of all branches of macro-superpositions requires an enormous amount of information.[171] Tegmark's thesis behind the claim that the universe contains little to no information could be pictured as a general digression of information being unraveled during state's temporal evolution (particularly the universal wavefunction). If Tegmark's thesis is going to work there must *actually* be an enormous amount of information frontloaded into the initial conditions. The information is not merely illusory—that's an epistemic issue and not an ontic issue. This initial information is surely complex. If it is going to decohere there must be some type of complexity to it. This hardly seems controversial. The question now is whether this information is specified. I contend that it must be the case that the initial information of the universe/multiverse must be highly complex and specified to be able to allow for the existence and function of subsystems within it (i.e. the information content in galaxies, planets, self-aware substructures, etc.). This information required for the smaller finite sets of information, on the micro and macro-superposition levels, must be loaded into the initial information content by which the subsets of information must originate.

By experience, it can be inferred that mind originates information (as previously described) and that the other competing hypotheses do not have the explanatory scope and power as FT does. It is by the means of abduction one can infer that FT is the best explanation for the data. Chance and randomness cannot substantially account for the data. The improbability alone is infinitesimally small. The necessity explanation has no support due to the logical possibility of multiverse scenarios being different then what they actually are; thus, Tegmark's postulate that mathematics is equivalent to physical existence is just that—a postulate.

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[170] Ibid. To avoid equivocation, it is necessary to distinguish "information content" from *mere* "information carrying capacity," "specified information" from *mere* "Shannon information," "specified complexity" from *mere* "complexity."

[171] Tegmark, "No Information," 27.

B. The Cosmic Origin of Information—Mind

This section will argue that brand new information can only be the consequence of an antecedent mind and that material or Platonic antecedents are insufficient to produce brand new information. This argument is an empirical and based on experience, which provides an uncontroversial premise (experience) used in the inferential reasoning process. The possible *explanans* are mind, phenomenal entities, or abstract entities. The options must meet the conditions of causal efficacy and specificity.[172] The first condition states that origin of information must be causal. Information does not arbitrarily pop in and out of existence but requires a source.[173] The second condition states that the origin must sufficiently explain the specificity in information and must provide more than mere Shannon information.

Consider a computer as an example for information relay (a phenomenal entity). The computer is and can be used as a channel, it can be a receiver, and it can be a source of information. However, to say that the information in the computer no longer needs an explanation for its origin would suffer the problem of information displacement—it pushes the problem back a step in explanation. What begs the question is identifying the source of information in the computer. The answer would inevitably become a software engineer or a programmer. Undirected material processes have not demonstrated the capacity to generate significant amounts of specified information.[174] Information can be changed via materialistic

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[172] An analogy may help illustrate these conditions. Information requires a source sent through a channel to a receiver (excluding noise). The analogy fits with the source being mind, phenomenal entities, or abstract entities. The causal relationship is the channel, the relay that allows the information to be applied to the receiver, which is physical reality.

[173] There is something known as 'self-information,' which, mathematically speaking, is entropy. The term can be misleading but merely refers to the probability distribution or uncertainty of a random variable. Cover and Thomas, 13, 21.

[174] Meyer, *Signature in the Cell*, 340-41.

means. The computer can change the initial coding from the programmer and introduce noise on the sending and receiving ends.

This takes it back to the role of abduction in my methodology. What is an adequate cause for the effect in question—the origin of cosmic information? Logically, one can infer the past existence of a cause from its effect, when the cause is known to be *necessary* to produce the effect in question. In the absences of any other known causes then the presence of the effects points unambiguously back to the uniquely adequate cause—a mind.[175]

Typically, empiricists will attempt to distance themselves from committing to the existence of abstract objects such as numbers.[176] However, Tegmark has a strict commitment to a metaphysical ontology of the Platonic ilk. Physicists are more likely to affirm the existence of abstract objects because the language of physics serves for the communication of reports and predictions and hence cannot be taken as a mere calculus in some cases. Those physicists who are suspect of the abstract as semantics in reference to real numbers as space-time coordinates or as values, functions, limits, etc.[177] The question present concerning the existence of abstract entities is not whether or not they exist. That's completely irrelevant to the argument and has a fair place at the table of *possibilia*. One must not rule out a possible explanation due to ontological insight eliminating options *a priori*.

The task in evaluating the plausibility of abstract entities as the best explanation for the origin of information is whether it meets the aforementioned conditions of causal efficacy and

[175] Ibid., 343.

[176] It is not my contention that Tegmark or the Platonist is inconsistent with their epistemology or ontology here since C.S. Peirce and Gottlob Frege were empiricists who embraced abstract entities. However, it is not common to find empiricists embracing this position.

[177] See Rudolf Carnap, "Empiricism, Semantics, and Ontology" in *Philosophy of Mathematics*. Eds. Paul Benacerraf and Hilary Putnam (Englewood Cliffs, NJ: Prentice-Hall, 1964), 233-43.

specificity. With regards to the causal efficacy of abstract entities, what experience could be used as a referent? Certainly, there is meaning behind the phrases, “There are *seven* cows in the field” or “The apple is *red*” since these merely commit to the existence of abstract universals. However, what meaning is there in statements like, “Seven caused eight,” “Three causes or conditions triangles,” or “Green caused blue?” What is more is not an abstract-to-abstract causation but the abstract-to-phenomenal causation. Such statements would be logically equivalent to “Red causes the color of the apple” or “Geometry causes cubes.” This answers the question of whether abstract objects can specify information. The ability to specify must meet the antecedent condition of causal capacity since the role of causation is analogous to the role of the channel. Information does not originate in the source and arrive at the receiver (physical reality) without a channel. Thus, abstract objects are not sufficient explanations for the origin of information.

Of the possible *explanans*, mind, phenomenal entities, or abstract entities, the former is the best explanation. Neither phenomenal nor abstract entities are sufficient in accounting for the origin of brand new information. If one wants to appeal to phenomenal or abstract entities then it becomes an issue of information displacement.

CHAPTER SIX: CONCLUSION—THE COMPATIBILITY OF THE FINE-TUNING ARGUMENT AND THE MULTIVERSE HYPOTHESIS

Although some of the laws of physics can vary in their constants from universe to universe in string or inflationary multiverse scenarios, these fundamental laws and principles underlie said scenarios and therefore cannot be explained as a multiverse selection effect. Further, since the variation among universes would consist of variation of the masses, and types of particles and the form of the forces between them, complex structures would almost certainly not be akin to our atomic structure and stable energy sources would almost certainly require aggregates of matter. Thus, the said fundamental laws seem necessary for there to be life in any of the many universes, not merely in a universe with our specific types of particles and forces.[178]

Anthropic principles lack in explanatory power. Multiverse selection effects are not sufficient to explain the random variables and states of affairs for any universe or observer within a universe. The mechanism responsible for the multiverse to function cannot be explained by the multiverse selection effect. The information content in the values of these laws and mechanism are specified and complex. The only known source of brand new information is a mind. There are no known antecedent material causes responsible for the origin of new information. Recall the original argument:

1) Given the fine-tuning evidence, a life permitting universe/multiverse (LPM) is very, very unlikely under the non-existence of a fine-tuner (~FT): that is, $P(LPM|{\sim}FT \,\&\, k') \ll 1$.
2) Given the fine-tuning evidence, LPM is not unlikely under FT (the fine-tuner hypothesis): that is, ${\sim}P(LPM|FT \,\&\, k') \ll 1$.
3) Therefore, LPM strongly supports FT over ~FT.

It is not the case that the premises strongly support the conclusion. It is the conclusion that supports the premises. With a mind being necessarily antecedent to the effect—information—there are sound reasons for the acceptance of FT being the best explanation for LPU/LPM. It is

[178] Robin Collins, "The Teleological Argument," 277.

not the case that fine-tuning is illusory based on the premise that life could adapt to very different conditions or if the values of constants could compensate each other if varied. This creates a problem of information displacement and does not provide a sufficient explanation for the mechanisms needed to produce the variation in nomic behavior, which requires fine-tuning to function. Appealing to a chance hypothesis is not a reasonable explanation since the probability of a functioning universe/multiverse is unfathomably small rendering LPU/LPM unlikely under ~FT. Additionally, suggesting that fine-tuning is nonexistent because nature could not have been otherwise is far-removed from the evidence. The nomic necessitarian is left with no explanation other than mere assertion as to why the values for the laws of nature are metaphysically necessary. Finally, cosmic Darwinism is not the best explanation for LPM, making the measured values quite likely within a multiverse, since it suffers the same defeat of the chance hypothesis and does not explain the functionality of the multiverse mechanisms. Physicists, cosmologists, and philosophers must accept the laws of nature and basic premises of inflationary cosmology and string theory with the best explanation being the fine-tuning hypothesis; that is, the plausible existence of a fine-tuner.

APPENDIX: THE MACROSCOPIC ONTOLOGY OF THE MANY WORLDS INTERPRETATION

Unlike any other interaction in nature, measurement has the power to collapse the wave function from many parallel possibilities to just one actual result. Everett leaves out the wave function collapse for every particle and uses what would be the wave function collapse as, what he calls, a proxy wave. When a quantum state interacts with a measuring device to measure a particular attribute it splits into many different waveforms. However, Everett maintains that there is a singular universal wave function. Everett maintains that each waveform becomes actualized.[179] There are three leading interpretations for the macroscopic ontology of MWI: literal fission, macroscopic pairing, and spacetime point pairing.

I. Literal Fission

Literal fission identifies persisting macroscopic[180] objects and events, called 'continuants,' with non-branching parts of a branching structure (branch segments), represented by a set of consistent histories.[181] Temporal parts are used to refer to branch segments, which account for *de re* claims. Simon Saunders and David Wallace suggest

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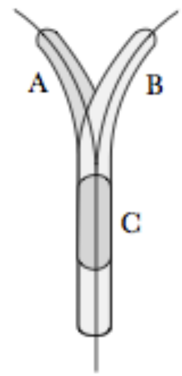
[179] Nick Herbert, *Quantum Reality: Beyond the New Physics* (New York: Random House, 1987), 172-73.

[180] When I refer to macroscopic objects I do not merely mean 'large' objects. By macroscopic I mean objects or events where quantum entanglement is unimportant or insignificant. Alastair Wilson, "Macroscopic Ontology in Everettian Quantum Mechanics," *The Philosophical Quarterly* 61 no. 243 (April 2011): 366. Erwin Schrödinger introduced quantum entanglement in a 1935 paper delivered to the Cambridge Philosophical Society in which he argued that the state of a system of two particles that have interacted generally cannot be written a s a product of individual states of each particle. $|\text{Particle A interacting with B}\rangle \neq |A\rangle|B\rangle$ (Here the ket symbol, $|\ \rangle$, refers to a quantum state as introduced by Paul Dirac—thus, $|\Psi\rangle$ refers to a quantum state.) Such a state would be an entanglement of individual states in which one cannot say with any certainty which particle is in which state (i.e. Schrödinger's cat illustration). Disentanglement occurs when a measurement is made. Allday, 374-75.

[181] Alastair Wilson, "Macroscopic Ontology in Everettian Quantum Mechanics," *The Philosophical Quarterly* 61 no. 243 (April 2011): 366.

> [‘*C*] might have *P*’ is true if and only if *C* has a temporal part that is a temporal part of a continuant *C*′ that has *P*… Thus Al Gore might have won the 2000 presidential US election, if he has a temporal part, which is a part of a person who won.[182]

Figure B1



This clearly has implications or agency. This allows for agent distinctions to be made at the moment of branching. Consider Figure B1[183] in which branch segments A and B share a common C. There are two continuant agents, one per branch, who share a common part before the measurement. Each states a truth claim, or utterance, but each does not know the corresponding truth-value of the claim because at the moment of branching, or measurement, each does not know which branch he belongs to (theoretically).[184]

The problem Alastair Wilson raises with literal fission is that it cannot account for uncertainly involved in future-tensed events relative to a particular branch segment. Suppose that after the death of agent A event X will occur. Events containing ~X will also contain the aggregate branch segments that make up A’s continuant. The question is how can A be certain about which branch is his and if X occurs within A’s branches? Wilson wants to claim that X’s uncertainty cannot be accounted for by literal fission.[185] Wilson argues that literal fission leads to serious problems for the application of modal semantics to future contingents. Literal fission identifies macroscopic objects and events with non-branching aggregates of branch segments but

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[182] S. Saunders and D. Wallace, “Branching Uncertainty,” *British Journal for the Philosophy of Science* 59 (2008): 298.

[183] Wilson, 366.

[184] Ibid., 367.

[185] Ibid., 367-68.

fails to ensure that macroscopic objects and entities have unique futures—a metaphysical pictures is required in which macroscopic continuants are uniquely bound to each branch.[186]

However, at the moment of branching, say, agent A is not identical to agent B but are metaphysical similar. The mere fact that A and B can be indexed from each other in a quantum state makes the metaphysical distinction. There seems to be a conflation of epistemic identity without regard to decoherence. There is only one persevering epistemic identity after branching. What I mean by that is that A believes he is A and B believes he is B and A does not believe he is B and B does not believe he is A. Neither agent would be truly confused about his present identity since decoherence prevents us from experiencing the branching split. A may be aware that B split from their common C and even though A and B share the same memory components, C, no confusion *should* be present. I suspect this may be one of the reasons why Wilson rejects literal fission because in my distinction each macroscopic entity has a unique branch and does not conflate or confuse present states of affairs nor does it create ontological uncertainty about future tensed events, though, certainly, there may be an epistemic uncertainty.[187]

II. Macroscopic Pairing

Building on a solution to the problem of literal fission the new picture must involve some relation in which each object or event stands to exactly one complete branch—this requirement is called the *branch-binding criterion*. This identifies macroscopic objects as pairs <branch *p*, continuant *q*>, where continuant *q* is a part of branch *p* in the sense employed by literal fission.[188] However, such an understanding has mereological consequences. Identifying objects

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[186] Ibid., 370.

[187] See footnote 126 for my discussion on probability.

[188] Specifically, this would appear as <your branch, your continuant>. The relation between branch-continuant and some branch is just inclusion: each branch-continuant includes only one branch. A branch-

as pairs then material objects and events have no proper parts.[189] For instance, indexing my hand is just an indexed pairing and not a proper part of my body. I would simply be the sum of my mereological parts. I would have no proper parts.

Modal and mereological distinctions create identity problems from branch to branch or from world to world. Michael Almeida and David Lewis suffer the mereological despair of being the sum of their parts and treat 'proper parts' as the whole of their subsets. Their modal distinctions are not merely conceptual (i.e. the abstract understanding of a possible world) but concrete in nature.[190] Thus, each branching segment/event is its own concrete possible world. In treating such mereological/modal distinctions and concrete the macroscopic pairing problems have a persevering identity, which meets the branch-binding criterion, but fails in indexing proper parts or persevering wholes. The 'whole' of a macroscopic object is the mereological sum of branch-identity-persevering parts. Thus, macroscopic pairing requires extra commitment to properties: where we may have thought there was a single property, macroscopic pairing requires us to admit two properties, one of which is had by a pair in virtue of the other being hand by the second element of the pair. As Wilson notes, this may not be an end-all defeater for macroscopic pairing but it does have heavy metaphysical consequences and, perhaps, adjustment to one's ontological jungle.[191]

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continuant *x* belongs to a world *w* if and only if *x* has a first element identical with each element of *w*. Wilson, 370-71.

[189] David Lewis' position is that pairs, sets, have all and only their subsets as proper parts. David Lewis, *Parts of Classes* (Oxford: Blackwell, 1991). Wilson, 371-72.

[190] Michael J. Almeida, *The Metaphysics of Perfect* Beings (New York: Routledge, 2008), 144-45. *Metaphysics of Perfect Persons*, "Theistic Modal Realism, Multiverses, and Hyperspace" (New York: Routledge, 2008), 135-164. David Lewis, "Counterparts of Persons and Their Bodies," in *Metaphysics* Ed. 2, Eds. Peter van Inwagen and Dean W. Zimmerman (Oxford: Blackwell, 2008), 511-518.

[191] Wilson, 373.

III. Spacetime Point Pairing

Similar to macroscopic pairing, spacetime pairing makes identifications to spacetime points.[192] A spacetime point would be a pair <*b*, *a*>, where *a* is a pointlike part of a branch and *b* is a complete branch.[193] The mereology of spacetime regions and macroscopic objects treats parthood in a way that treats my hand as a proper part of my body. The branch-binding criterion is satisfied since objects and events are identical with fusions of spacetime points and each of the spacetime points is branch-bound by virtue of its inclusion of a branch as an element.[194] This seems to fit my criticism and reservation from literal fission. Metaphysical distinctions can be drawn where branch segment A is metaphysically distinct from branch segment B even though they both share the common pre-branching segment C. Treating the branch segments as agents, A and B share the same mental state/memory components as C but become metaphysically similar to each other—identity distinctions are preserved.

Wilson raises the question of parthood in the objection to macroscopic pairing and compares it to spacetime point pairing.[195] Though the objection could be pressed Wilson claims

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[192] Under this proposal, the 'spacetime' is of the quantum mechanics and quantum field theory formalism, in terms of which branches are defined, is not the same as the 'spacetimes' of macroscopic worlds. The spacetime of quantum mechanics is a single entity common to multiple branches, while each of the macroscopic spacetimes is tied to a particular macroscopic course of events. The proponent of spacetime point pairing should refer to the term 'spacetime' as the emergent entity linked to individual branches and use 'pre-spacetime' for the fundamental entity common to branches (as in C in Fig. 1). Ibid., 375.

[193] Wilson advocates for a supersubstantivalist view, which identifies material objects and events directly with spatiotemporal regions, and then identifies spatiotemporal regions with mereological fusions of spacetime points. Ibid., 373-74.

[194] Ibid., 374.

[195] Additionally, Wilson argues that this has an advantage over literal fission because it can account for objective probability claims. Wilson, 375. I do not see the necessity of preserving objective probability (i.e. Born's rule). It may keep for a tidy explanation by accommodating the rule but I believe a philosophically robust interpretation can treat one's physical ontology as deterministic and rest probability calculations at the feet of epistemic limits.

the problem less damning. If pairs are mereological simples (or basic mereological units), then spacetime points will have no parts. If pairs are treated as sets, and that sets have subsets as parts, then each spacetime point has as parts the single basic set containing an entire branch, and the single basic set containing a pointlike part of that branch.[196]

IV. A Final Assessment

As previously mentioned, weirdness is not an appropriate objection to MWI. Tegmark placed such objections in the forbidden category[197] and Lewis called it the 'incredulous stare,'[198] to which he wittedly offered no response. However, there may be more than weirdness and stares that conflict with pairing options (both macroscopic and spacetime point).

The first objection is from phenomenology—we do not *feel* like we are pairs and that we ourselves exist as a proper whole. The problem is that we do not really know what it would be like to be a pair. What would being a pair be like? Without knowing that, how can the objection that our phenomenological experiences conflict with pairings?[199] It seems that the burden of proof is on the objector to demonstrate what pairings would feel like, if contrary to the possibility that we currently are pairings, and how this conflicts with phenomenological experience.

The second common objection is that branch-continuants are unnatural. In Lewisian terms, naturalness is a fundamental property of properties. So, being a branch-continuant is less natural than being a continuant. Thus, we should reject semantics according to which branch-

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[196] Ibid., 374.

[197] Max Tegmark, "Is "The Theory of Everything" Merely the Ultimate Ensemble Theory?" arXiv:gr-qc/9704009v2 (Dec. 1998): 28. "The Multiverse Hierarchy," 8-10.

[198] David Lewis, *On the Plurality of Worlds* (Oxford: Blackwell Publishers, 1986), 133-35.

[199] Wilson, 376.

continuants are taken to be there referents of our ordinary object-terms and event-terms.[200] In Everettian quantum physics, identity referents such as branch-continuant are the best option for metaphysical indexing. Being a mere continuant does not help solve the issue either.

The third reservation is that we are treating pairs as abstract objects whereas we are concrete. Under the macroscopic pairing proposal, concrete objects are a species of the abstract. The abstract pair <my branch, aggregate of my branch segments> is identified with a concrete object—me.[201] This obviously creates ontology problems as well as the need to accept abstract to concrete causation. Spacetime points seem to dilute the problem by being between abstract and concrete, if such a region is permitted. Perhaps, the best response to this is adopting a critical realist position on branching. Yes, the branching actually occurs but our indexing of quantum moments is semantic approximations in describing what is actually occurring. Using pairs is a useful fiction for describing what is actually occurring during the branching event without saying that the branching event is simply a mathematical model for epistemic purposes (adopting an anti-realist position). This approach also lessens the blow to the fourth objection, that pairs are arbitrary. The order of the elements contained within the set is irrelevant and may be moved.[202] Nevertheless, it remains useful for indexing what is actually occurring.

The macroscopic point pairing and the spacetime point pairing seem to be the best candidates for understanding the macroscopic ontology of MWI by preserving identity and metaphysical distinction. What *does not* occur is that at certain magical instances, the world undergoes some sort of metaphysical 'split' into two branches that subsequently never interact. According to MWI there is, was, and always will be only one wavefunction, and only

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[200] Ibid., 377.

[201] Ibid., 377.

[202] Ibid., 378-79.

decoherence calculations can tell us when it is a good approximation to treat two branches as non-interacting.[203] The universal wave function evolves smoothly and deterministically over time without any kind of splitting or parallelism. The abstract quantum world described by this evolving wave function contains within it a vast number of parallel classical story lines, continuously splitting and merging, as well as a number of quantum phenomena that lack a classical description. After each branch-split event the spacetime point pairing, or even on a larger scale, your doppelgänger lives on another quantum branch in infinite-dimensional Hilbert space.[204]

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[203] Max Tegmark, "The Interpretation of Quantum Mechanics: Many Worlds or Many Words?" arXiv:quant-phy/9709032 (Sep 1997): 2.

[204] Max Tegmark, "Many Worlds in Context," arXiv:0905.2182 (Mar 2010): 10-11.

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