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ORIGINAL RESEARCH

Planetary fine-tuning, cosmological fine-tuning, and the multiverse

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Abstract
Many philosophers and scientists take cosmological fine-tuning—roughly the fact that our universe would have been devoid of life if it had had slightly different cosmological parameters—to point to the existence of a designer or multiverse. Planetary fine-tuning—roughly the fact that our planet would have been devoid of life if it had slightly different intrinsic characteristics or relations to other objects in the solar system—points to the existence of many planets. It may seem that since astronomy independently confirms the existence of many planets, planetary fine-tuning is of less philosophical interest than cosmological fine-tuning. This paper shows that any such appearance is illusory by defending four arguments for the conclusion that our planetary fine-tuning evidence supports the existence of a multiverse.

Keywords Fine-tuning · The multiverse hypothesis · Inverse gambler's fallacy · Arguments for a multiverse · Ideal rationality · Enumerative induction · Explanatory unification · Ensemble explanations

1 Introduction

We seem to have won not one, but *two* large-scale lotteries: our universe and our planet are fine-tuned for (intelligent) life. That is, their respective parameters seem to fall within the exceedingly narrow portions of cosmological and planetary parameter spaces that are hospitable to life.

Many philosophers and physicists take cosmological fine-tuning to invite an extraordinary explanation in terms of—and so to support the existence of—a multi-

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verse or designer.[1] Planetary fine-tuning seems to invite a more conservative explanation. The explanation holds that planetary fine-tuning is to be expected given *the many planets hypothesis* that our universe contains a large and varied set of planets. Unlike the existence of a multiverse or designer, the many planets hypothesis is well-confirmed by astronomical observations and relatively uncontroversial.[2] That's why the many planets explanation is more conservative. Despite this difference, the many planets explanation of planetary fine-tuning structurally parallels the multiverse explanation of cosmological fine-tuning. The latter holds that cosmological fine-tuning is to be expected, given *the multiverse hypothesis* that there exists a multiverse, i.e. a large and varied set of universes.

Planetary fine-tuning has received far less attention from philosophers than cosmological fine-tuning.[3] A natural diagnosis of this discrepancy is that, in contrast to its cosmological cousin, planetary fine-tuning seems not to have potential implications for anything as philosophically interesting as a multiverse or designer. This appearance is illusory. Or so I'll argue. My arguments will not rely on the contention of some intelligent design proponents that the many planets explanation is defective and should therefore be rejected in favor of a design hypothesis.[4] On the contrary, I will assume that the many planets hypothesis explains planetary fine-tuning and hence that explaining planetary fine-tuning does not require explanation in terms of an extraordinary posit. Having assumed this, I will then bring our planetary evidence—meaning the discovery of planetary fine-tuning and the observational evidence that renders the many planets hypothesis well-confirmed—to bear on the multiverse hypothesis. Specifically, I'll argue that our planetary evidence also supports that hypothesis.

My arguments work most straightforwardly on the assumption that cosmological fine-tuning supports the multiverse hypothesis. But whether cosmological fine-tuning provides any support for the multiverse hypothesis is a matter of ongoing controversy.[5] So, drawing on some recent work, I'll start by briefly arguing that cosmological fine-tuning supports the multiverse hypothesis and that this should be less controversial than it is (§ 2). I'll then trace four argumentative paths by which our planetary evidence supports the multiverse hypothesis. The arguments are indirect in that they hold that our planetary evidence supports the multiverse hypothesis by amplifying the extent to which cosmological fine-tuning supports the multiverse hypothesis. The first argument claims that our planetary evidence supports the multiverse hypothesis

[1] For an overview of the philosophical literature on cosmological fine-tuning, see Friederich (2021).

[2] There are an estimated 2,000,000,000,000 galaxies in the observable universe, on the order of 10^8 to 10^{14} stars per galaxy, and an average of at least one planet per star (Conselice et al. (2016); Uson et al. (1990); Cassan et al. (2012)). Current cosmological models are also compatible with our universe containing infinitely many planets—see, e.g., Greene (2011: Ch. 2).

[3] But in-depth discussions of the analogy between the many planets explanation and multiverse explanations can be found in Manson and Thrush (2003), Huemer (2018: § 11.4.2), and Friederich (2019a)—see also Kinouchi (2015). Greene (2011: Ch. 6) and Parfit (2011: 627-8) discuss the analogy in passing. Leslie (1989: 131-2) and Monton (2009: Ch. 3) discuss both cosmological fine-tuning and a many planets explanation of life's origin.

[4] See, e.g., Behe (2007: Ch. 10).

[5] See Manson (2022).

by undercutting an influential objection to cosmological fine-tuning supporting that hypothesis (§ 3). The second argument claims that our planetary evidence enables cosmological fine-tuning to further support the multiverse hypothesis via enumerative induction (§ 4). The third argument holds that planetary fine-tuning supports the multiverse hypothesis by bestowing a virtue of unification on the multiverse explanation of cosmological fine-tuning (§ 5). The fourth argument claims that our planetary evidence confers a predictive advantage on the multiverse hypothesis by indicating that our universe is not optimized for life, despite being cosmologically fine-tuned (§ 6).

Before proceeding, I will briefly offer some background on some empirical facets of fine-tuning. While my arguments can be understood without this background, it may nonetheless provide helpful context. Candidates for fine-tuned cosmological parameters include the relative strengths of fundamental forces, the cosmological constant, the homogeneity of initial conditions, and the low entropy of initial conditions.[6] Candidates for fine-tuned planetary parameters include planetary mass, axial tilt and stability, orbital stability, distance from host star, type of host star, chemical composition and distribution (e.g. liquid water on the planet's surface), plate tectonics, moon size, and shielding properties afforded by the planet's magnetic field, a suitably located Jupiter-like planet in the same solar system, and/or a galactic location.[7] There is ongoing scientific and philosophical debate about which parameters are fine-tuned and to what extent. Even so, providing scientific evidence that certain parameters such as those listed above are fine-tuned is the main way of supporting cosmological and planetary fine-tuning.

However, not all scientific evidence for fine-tuning concerns a specific parameter. In the planetary case, two striking data points that do not concern any specific planetary parameter support planetary fine-tuning. First, we find ourselves in a universe with an enormous number of planets but no signs of extraterrestrial (intelligent) life, despite SETI efforts to find such signs.[8] Second, we find ourselves on a planet where intelligent life evolved on a timescale on the same order of magnitude as the lifetime of the planet. This striking coincidence can be elegantly explained with an observation selection effect on the assumption that conditions for intelligent life emerging on planets are extremely stringent: given that assumption, it is to be expected that on the rare occasions when life emerges on a planet, it emerges on the same time scale as the planet's lifetime rather than very early in the planet's history.[9]

[6] For an accessible presentation of the physics relevant to cosmological fine-tuning, see Lewis and Barnes (2016).

[7] For an influential presentation of evidence for planetary fine-tuning, see Ward and Brownlee (2000). For more-recent discussion of such evidence, see Vacca (2025). For a discussion of planetary fine-tuning that is a precursor to discussions of cosmological fine-tuning, see Wallace (1904).

[8] See, e.g., Sandberg et al. (2018).

[9] See Carter (1983) and Snyder-Beattie et al. (2021).

2 Cosmological fine-tuning supports the multiverse hypothesis

As noted in § 1, it is controversial whether cosmological fine-tuning provides any support for the multiverse hypothesis. The locus of the controversy is *the this-universe objection*.[10] According to this objection, a multiverse would merely explain and raise the probability of *some* universe being fine-tuned; it would not explain or raise the probability of *this (our)* universe being fine-tuned; since the latter is our relevant cosmological fine-tuning evidence, our cosmological fine-tuning evidence does not support the multiverse hypothesis.

Replies to the this-universe objection are legion.[11] In my view, it should be uncontroversial that cosmological fine-tuning supports the multiverse hypothesis—at least for all the this-universe objection says. While I find many of the replies plausible,[12] it is not because I am convinced of any of these replies that I hold the noted view. Instead, I claim that if we take a step back from the debate and distinguish two notions of support, it's easy to see how cosmological fine-tuning supports the multiverse hypothesis in one interesting sense of "support".[13]

Here's the distinction. Evidence *ideally supports* a hypothesis by justifying an ideal agent (one who makes no mistakes in reasoning and has unlimited cognitive capacities) in boosting their confidence in that hypothesis. In contrast, evidence *non-ideally supports* a hypothesis by justifying us (i.e. fallible agents with limited cognitive capacities) in boosting our confidence in that hypothesis.[14] To take a stock example, consider testimonial evidence that Goldbach's conjecture has been proven. Such evidence would non-ideally support the hypothesis that that conjecture is provable. However, that evidence could fail to ideally support that hypothesis since an ideal agent could reason her way to rational certainty about the truth or falsity of the conjecture and therefore be unmoved by the testimonial evidence.

While this distinction usually goes undrawn in discussions of cosmological fine-tuning, proponents and opponents of the this-universe objection can be charitably interpreted as disagreeing—at least in the first instance—about whether cosmological fine-tuning ideally supports the multiverse hypothesis. Suppose so. Then I grant that it should be controversial whether the this-universe objection succeeds and hence whether cosmological fine-tuning ideally supports the multiverse hypothesis.

[10] Variations of this objection are advocated by Hacking (1987), Olding (1990), Dowe (1999), White (2000, 2003), Sober (2004), Draper et al. (2007), Collins (2009), Plantinga (2011), Landsman (2016), Draper (2020), and Goff (2021). For an overview of the literature on the objection, see Manson (2022).

[11] See McGrath (1988), Bostrom (2002: 22), Manson & Thrush (2003), Juhl (2005), Bradley (2009, 2012), Epstein (2017), Huemer (2018: Ch. 11), Friederich (2019a, b), and Isaacs et al. (2022).

[12] My preferred reply is: (1) positing striking but unexplained coincidences is a theoretical vice, (2) on our cosmological fine-tuning evidence, that vice is manifest by the single-universe hypothesis but not the multiverse hypothesis, and (3) because differences in theoretical vices make for differences in epistemic probabilities, our cosmological fine-tuning evidence thereby confirms the multiverse hypothesis over the single-universe hypothesis—cf. Acuña (2014), Bostrom (2002: 35−6), Carter (1983), Cutter and Saad (2023: § 3), Leslie (1989), and Friederich (2019b).

[13] I defend this claim in more depth elsewhere (Saad, 2024a).

[14] A distinction along these lines is, however, sometimes drawn in epistemology—see, e.g., Field (2000: 117), Schoenfield (2012: *passim*), and Smithies (2015). For defense of a variation of this distinction, see DiPaolo (2019).

In light of this controversy, we should be uncertain whether cosmological fine-tuning ideally supports the multiverse hypothesis. However, given rational uncertainty about whether cosmological fine-tuning ideally supports the multiverse hypothesis, cosmological fine-tuning should lead us to boost our confidence in the multiverse hypothesis. To see this, consider the following case:

Uncertainty: You know:

- A fair coin was flipped to determine the size of a team of dice rollers, each member of which will roll a pair of dice.
  - If it lands on the side labeled "ONE ROLLER", the team has just one member.
  - If it lands on the side labeled "TWO ROLLERS", the team has exactly two members.
- Another fair coin was flipped.
  - If that coin lands on the side labeled "NEUTRAL", then you are assigned a roller; if she rolls a double six, you will wake up and observe this; otherwise, you won't wake up.
  - If that coin lands on the side labeled "CONFIRMATION", then if at least one dice roller observes a double six you will awaken to observe a double six; otherwise, you won't wake up.

You wake up and observe a double six.[15]

In this case, the first coin toss models uncertainty about whether there is one universe or more than one; the second coin toss models uncertainty about whether cosmological fine-tuning ideally supports the multiverse hypothesis; and your waking up in the event of a double six models our fine-tuning evidence.

Notice that, conditional on NEUTRAL, how many rollers there are does not affect the likelihood of your observation. In contrast, conditional on CONFIRMATION, your observation is more likely if there are more rollers, i.e. two rather than one. So, your observation supports the multiple rollers hypothesis. Our epistemic situation is analogous. So, our cosmological fine-tuning evidence non-ideally supports the multiverse hypothesis.

[15] This case embeds two cases from White (2000, 2003), one of which is due to McGrath (1988: 265), corresponding to the NEUTRAL and CONFIRMATION conditions—see my (2024: § 5). In that paper, I offer a more sophisticated model that captures additional features of our epistemic situation (ibid.: § 7). To keep the discussion tractable, I'll just work with his simpler model here.

3 The shielding argument

My first argument builds on an intriguing reply to the this-universe objection due to Manson & Thrush (2003). Here's their reply:

> when it comes to explaining the fitness of the Earth for life, accounts that appeal to the vast number of planets in our universe (and hence the vast number of chances for conditions to be just right) surely are not to be faulted for failing to explain why this planet is the fit one. Clearly the "This Planet" objection (TP) is no good… How is [the this-universe objection] any different from TP? (ibid.: 73)

This is a powerful and underexplored challenge to the this-universe objection. To appreciate the force and import of the challenge, we need to ask: what exactly is wrong with the this-planet objection? Here's what they say:

> TP is not cogent because when we set aside all of the features of the Earth that are essential to its ability to produce living creatures… there is otherwise nothing special about it. There might have been something special about the Earth. For example, it could have been that only from the vantage point of the Earth would one see that the constellations spell out "THIS UNIVERSE IS GOD'S HANDIWORK." But absent such a special feature, there is no motivation for the demand to explain why this particular planet, the Earth, is fit for life. (ibid.)

Note that if Earth—rather than another planet—being fine-tuned fails to demand explanation, that is not a reason for thinking that the many planets hypothesis explains it. If anything, the absence of a demand for such an explanation should lower our confidence that there is one.

I gather that what Manson and Thrush instead have in mind is that the many planets hypothesis adequately explains (or obviates the need to explain)[16] Earth's fine-tuning, provided that there is nothing distinctive about Earth that makes it striking that Earth rather than another planet is fine-tuned. That may be true. But it is not a priori obvious that the many planets hypothesis yields such an explanation. To see this, it may help to consider the proposed explanation from the perspective of an ancient human who does not know that Earth is fine-tuned and has no reason to believe that there are many planets. From this perspective, you contemplate the hypotheses that Earth is fine-tuned and that there are many planets. And you consider whether the many planets hypothesis would adequately explain Earth's fine-tuning in scenarios where both hypotheses are true. The many planets hypothesis strikes you as holding prima facie explanatory promise with respect to the Earth's fine-tuning. After all, Earth's fine-tuning would seem less striking if there were many planets than if there were few. Even so, from this perspective, I suggest it is not obvious whether the many

[16] Rather than make this qualification repeatedly, I'll use 'explain' broadly so that a hypothesis counts as explaining evidence if the evidence is striking unconditionally but not conditional on that hypothesis.

planets hypothesis would explain or raise the probability of Earth's fine-tuning, even conditional on Earth lacking a special property.

Here's my alternative diagnosis: while it is a priori unobvious whether the many planets hypothesis would adequately explain our planetary fine-tuning evidence, we have powerful empirical evidence that it does so. The crucial empirical discoveries are that our planet is fine-tuned and that the many planets hypothesis is true. If the apparent explanatory connection between these facts is borne out in an adequate explanation of the former by the latter, then these discoveries are unsurprising. On the other hand, absent such an explanation, these discoveries constitute a remarkable and highly misleading coincidence.

Compare: I am currently ignorant about whether there is a hole in my floor and about whether Bruce poured his favorite chemical on my floor. I find it a priori unobvious whether a hole in my floor would be explained by Bruce pouring his favorite chemical on my floor—for all I know, his favorite chemical might be non-corrosive. I later discover that there is a hole in my floor and that Bruce poured his favorite chemical on my floor. Evidently, I have acquired powerful evidence that Bruce pouring his favorite chemical on my floor would explain the hole in it, even if I remain ignorant of how his favorite chemical explains the hole in my floor. I could reject this explanation only by countenancing a remarkable and highly misleading coincidence between the hole and the pouring. Here too there is powerful evidence for an explanatory connection that was initially doubted and which is still not fully understood.

With this diagnosis in hand, we can bolster the this-planet reply to the this-universe objection as follows. Discovering planetary fine-tuning and the truth of the many planets hypothesis provides—at least for non-ideal agents like ourselves—strong evidence that the truth of the latter would explain and raise the probability of the former, and that the this-planet objection fails. But that explanation is of the same kind as the multiverse explanation of cosmological fine-tuning: both explain a form of fine-tuning for life by positing a large and varied ensemble that renders such fine-tuning to be expected; and both face a this-entity objection. So, discovering planetary fine-tuning and the truth of the many planets hypothesis also provides strong evidence that the this-universe objection fails and that the truth of the multiverse hypothesis would explain and raise the probability of cosmological fine-tuning. Gaining evidence for the failure of the main objection to cosmological fine-tuning supporting the multiverse hypothesis lessens the extent to which that objection attenuates that support. Equivalently, such evidence amplifies that support. So our planetary evidence amplifies the extent to which cosmological fine-tuning supports the existence of other universes.

The argument can be put in non-dialectical terms as follows. As a rule of thumb, gaining evidence that a hypothesis would explain and raise the probability of your evidence should lead you to increase your confidence in that hypothesis. A notable exception is when you are already extremely confident in that hypothesis; then there's little room left to boost your confidence in it. An exception of this sort can perhaps be found in our situation with respect to the many planets hypothesis: learning that the many planets hypothesis would explain and raise the probability of our planetary fine-tuning evidence doesn't justify much of a boost in our confidence in that hypothesis if we are already extremely confident in it prior to noticing its bearing on plan-

etary fine-tuning. In contrast, in the cosmological case we have not independently confirmed the existence of other universes. So we do not have antecedent grounds for extreme confidence in their existence. Thus, the rule of thumb applies: it dictates that evidence for the multiverse explaining and raising the probability of our cosmological fine-tuning evidence should raise our confidence in that hypothesis. Since our planetary evidence qualifies as such evidence by telling against the this-universe objection, it supports the multiverse hypothesis.

Before turning to the next argument, I will address an objection. The objection begins by noting that discovering ensembles along with phenomena that admit of explanations in terms of those ensembles generally does not lend significant support to the multiverse hypothesis. For example, suppose your grandchild shows you their profile picture on a social media app on their phone. You notice that your grandchild looks unusually good in the picture—that is, they look even better than they normally look. You are not one to keep up with newfangled phenomena such as profile pictures, social media apps, and smartphones. Indeed, you stopped following technological developments at a time when such a picture almost certainly would have been taken by a professional photographer. But your grandchild informs you that the profile picture was not taken by a professional photographer. This prompts you to speculate about a possible alternative explanation: perhaps your grandchild instead looks unusually good in their profile picture because that picture was selected from a large and varied ensemble of pictures of your grandchild taken by an amateur. You ask your grandchild whether there was such an ensemble. The answer is yes: the profile picture belongs to an ensemble of 'selfies'—i.e. pictures of a person that are somehow taken by that very person—depicting your grandchild. Your photographic evidence—that is, your grandchild looking unusually good in their profile picture and the existence of a selfie ensemble—gives you strong evidence that the selfie ensemble explains and raises the probability of your grandchild looking unusually good in their profile picture. However, your photographic evidence clearly has little (if any) bearing on the multiverse hypothesis. Hence, it is not strong evidence that the truth of the multiverse hypothesis would explain and raise the probability of our cosmological fine-tuning evidence; nor is it strong evidence against the this-universe objection. But your photographic evidence is relevantly like your planetary evidence: both encode the discovery of a striking phenomenon and an ensemble that is apt to explain it. Therefore, the objection continues, given this parallel and that your photographic evidence has little bearing on the multiverse hypothesis, the same goes for your planetary evidence: contrary to the above shielding argument, planetary evidence does not provide strong evidence that the truth of the multiverse hypothesis would explain and raise the probability of our cosmological fine-tuning evidence; and it does not provide strong evidence against the this-universe objection.[17]

In reply, there is much to agree with in this objection. Intuitively, your photographic evidence lacks strong evidential bearing on whether the multiverse hypothesis would explain or raise the probability of our cosmological fine-tuning evidence. Your photographic evidence also seems not to have strong bearing on the this-universe objection. And your photographic and planetary evidence are indeed parallel

[17] I thank a reviewer for an objection and example along these lines.

in that both encode the discovery of a striking phenomenon and an ensemble that is apt to explain it. However, there are also important differences between your photographic and planetary evidence. Reflecting on these differences will help to clarify what enables our planetary evidence to bear on the multiverse hypothesis in a manner that other, more mundane ensemble explanations do not.

One key difference is that the selfie ensemble explanation accounts for a profile picture. In contrast, the many planets and multiverse explanations both account for forms of fine-tuning for life. Thus, the many planets explanation and the multiverse explanation are much more similar to one another in terms of what they explain than either is to the selfie explanation. Consequently, the standing of the many planets explanation has significantly more evidential bearing on the standing of the multiverse explanation than does the standing of the selfie ensemble explanation.[18] By the same token, evidence that the this-planet objection to the many planets explanation fails is better evidence that the this-universe objection to the multiverse explanation fails than is evidence that a this-profile-picture objection to the selfie ensemble explanation fails.

Another difference is that the many planets and multiverse explanations account for something (fine-tuning for life) on which our existence as observers depends. As a result, their viability is sensitive to delicate issues—and ones that are debated in connection with the this-universe objection—concerning observation selection effects, i.e. selection effects that operate through conditions on the existence of observers.[19] Because evidence that the many planets explanation is correct implies that it does not fall prey to these issues, your planetary evidence encourages optimism that the multiverse explanation doesn't either. In contrast, the selfie explanation does not explain something on which your existence depends. Hence, it does not raise issues involving observation selection effects. For this reason, your photographic evidence for the selfie ensemble explanation fails to encourage optimism that the multiverse explanation does not fall prey to these issues.[20]

A final difference is that the selfie explanation is but one representative member of a vast class of correct ensemble explanations of mundane phenomena. (Consider, for example, lottery winners, everyday coincidences, and good pictures of sporting events.) This suggests that any bearing your photographic evidence has on the multiverse hypothesis and this-universe objection should be very modest, as it should be crowded out by many (correct, mundane) ensemble explanations that bear similarly on the multiverse hypothesis and the this-universe objection and which you knew

[18] The situation is symmetric in that it's also the case that the standing of the selfie explanation would—owing to the selfie explanation's greater similarity with other photographic ensemble explanations—have significantly more evidential bearing on other photographic ensemble explanations than would the standing of the many planets and multiverse explanations.

[19] See, e.g., Isaacs et al. (2022: § 2, § 6) and references therein.

[20] The selfie explanation does involve a more straightforward selection effect: you observe a picture in which your grandchild looks unusually good rather than a picture in which they don't look unusually good because there's selection for the former. But this is not an observation selection effect: the selection is between pictures that are all entirely compatible with your existence as an observer.

about prior to acquiring your photographic evidence.[21] In contrast, there is a dearth of candidate ensemble explanations of fine-tuning for life. For this reason, the impact of your planetary evidence on the multiverse hypothesis and the this-universe objection is—unlike your photographic evidence—not crowded out by other similarly relevant ensemble explanations that we have already taken into account.

To summarize, your planetary evidence has several features that distinguish it from evidence concerning mundane ensemble explanations and distinctively poise it to bear on the multiverse hypothesis and this-universe objection. First, like your cosmological evidence but unlike your photographic evidence, your planetary evidence concerns an ensemble explanation that targets fine-tuning for life. Second, your planetary evidence concerns an ensemble explanation that is—like the multiverse explanation but unlike many mundane ensemble explanations—entangled with observation selection effects. Third, because the many planets explanation is one of the few available ensemble explanations that targets fine-tuning for life, its impact on the multiverse hypothesis and the this-universe objection is unlikely to be crowded out by other similarly relevant explanations that we have already taken into account.

4 The inductive argument

In the previous section we saw that planetary fine-tuning supports the multiverse hypothesis by providing evidence that the multiverse is apt to explain cosmological fine-tuning. I'll now argue that planetary fine-tuning also independently supports the multiverse hypothesis via enumerative induction.

As a warm-up exercise, consider the following iterated version of our scenario. We start by observing a single instance of fine-tuning, but we are not yet in a position to check whether there is an associated ensemble. At this stage, we have not observed a correlation between fine-tuning and ensembles. So fine-tuning provides no support for an ensemble hypothesis by way of enumerative induction. However, we sequentially investigate ever larger entities that we inhabit: for vividness, we can imagine coming into existence on a small patch of terrain that we discover to be fine-tuned and proceeding to make corresponding discoveries about our island, our archipelago, and so on, eventually discovering our planet to be fine-tuned. After dozens of such investigations, a strong correlation emerges: whenever an investigation reveals an entity that is fine-tuned for life, lo and behold there is also a large and varied ensemble of entities of that kind, most members of which are not fine-tuned for life. A subsequent investigation then turns up another entity that is fine-tuned for life. We have not checked whether the observed correlation between fine-tuning and ensembles will hold for this particular instance of fine-tuning.

Under such circumstances the discovery that that entity is fine-tuned would provide compelling evidence for the existence of an associated ensemble. This is so even

[21] But we can perhaps imagine a case in which the selfie explanation is the first ensemble explanation that a person empirically confirms. In that case, evidence for the selfie explanation plausibly *does* provide strong evidence that the truth of the multiverse hypothesis would explain and raise the probability of our cosmological evidence.

if we are not in a position to observe the ensemble associated with the entity. This is a straightforward application of enumerative induction. However, it is a short step from accepting this application to accepting that planetary fine-tuning amplifies the extent to which cosmological fine-tuning supports the multiverse hypothesis.

To take that step, we need only assume that the size of the inductive base makes no difference to *whether* it generates inductive support—though larger inductive bases will, of course, tend to generate *more* support. Taking this assumption on board, let's consider a variation of the case that involves a single iteration: we observe a single instance of fine-tuning along with an associated ensemble. We then observe a second instance of fine-tuning but have not checked whether it is accompanied by an associated ensemble.

The difference between this circumstance and the corresponding one in the iterated case is just the size of the inductive base.[22] So, given that size of inductive base is immaterial and that the ensemble hypothesis was supported via enumerative induction in the iterated case, the ensemble hypothesis in this case also enjoys such support. But this case mirrors our epistemic situation: we have observed an instance of fine-tuning (namely planetary fine-tuning), an associated ensemble (the one posited by the many planets hypothesis), and another instance of fine-tuning (cosmological fine-tuning) without checking whether the latter instance of fine-tuning is accompanied by an associated ensemble (the multiverse). Given this parallel, we should conclude that planetary fine-tuning enables cosmological fine-tuning to support the multiverse hypothesis via enumerative induction. Or, more briefly: planetary fine-tuning (indirectly) supports the multiverse hypothesis.

While this argument may also suggest that the multiverse hypothesis explains cosmological fine-tuning, it is not beholden to that suggestion. To see this, suppose that in the iterated case an oracle tells you that ensembles do not explain fine-tuned neighborhoods. This might prompt you to look for a common cause. Or it might enhance the appeal of certain Humean theoretical packages that embrace unexplained correlations. But it would not prevent cosmological fine-tuning from supporting the multiverse hypothesis via enumerative induction.

To conclude my presentation of the inductive argument, let us consider the following objection (which I owe to a reviewer): planetary fine-tuning's would-be inductive support for the multiverse hypothesis is undercut by a counterexample to the inductive generalization at issue. The alleged counterexample is: fine-tuning of organisms to their environments is explained by natural selection rather than an observation selection effect.

My reply is threefold. First, a counterexample to an inductive generalization does not automatically block projection from instances of that generalization: I have inductive support for believing that the sun will rise tomorrow even though I know that it will not rise a trillion years from now. Second, the inductive generalization at issue in the first instance concerns fine-tuning and ensemble hypotheses, not fine-tuning and observation selection effects. Third, natural selection yields ensemble explanations

[22] Or so I grant for the sake of argument. A larger inductive base could be generated by distinguishing different sets of fine-tuned planetary parameters.

of organism-environment fine-tuning. So, natural selection offers another instance of the generalization rather than a counterexample to it.[23]

5 The unification argument

My next argument holds that our planetary evidence supports the multiverse hypothesis by enhancing its explanatory credentials. Specifically, I claim that our planetary evidence enables the multiverse hypothesis (but not rival views) to give a more *unified* explanation of fine-tuning than it otherwise would. More unified explanations are to be preferred (all else equal). So, our planetary evidence supports the multiverse hypothesis.[24]

To develop this argument, I need to say how our planetary evidence facilitates explanatory unification. As a preliminary, note that there is a sense in which planetary fine-tuning *on its own* facilitates unification: given that a suitably vast and varied multiverse could explain cosmological fine-tuning, so too could such a multiverse explain planetary fine-tuning; it could do so by featuring enough planets within its universes for planetary fine-tuning to be expected. Thus, planetary fine-tuning lends to unification by way of explaining diverse forms of fine-tuning in terms of a single explanans (the multiverse). However, our *other* planetary evidence arguably deprives the unity of the resulting multiverse explanation of much of its appeal: observational evidence renders the many planets hypothesis well-confirmed and so threatens to render explanatorily redundant the unifying part of the multiverse explanation that accounts for planetary fine-tuning. I say 'arguably' because the extent to which our evidence for the many planets hypothesis in this fashion deprives the multiverse explanation of planetary fine-tuning of its appeal depends on the number of planets in our universe and the degree of planetary fine-tuning supported by our evidence. If it turns out that there are too few planets or too high a degree of planetary fine-tuning, then the many planets hypothesis will not fully explain planetary fine-tuning, in which case there will remain room for the multiverse to help explain both planetary and cosmological fine-tuning. Whether our planetary evidence supports the multiverse by enabling this form of unification is a question that I will leave open.

My argument concerns a different variety of unification. The variety in question uses a single explanatory pattern to account for disparate phenomena,[25] albeit via distinct explanantia. Theories that nicely exemplify this form of unification include evolution by natural selection and the germ theory of disease. In the case at hand, we can put the explanatory pattern as a schema: fine-tuning fact F obtains because there is a suitably vast and varied ensemble E such that most of E's members are

[23] A more pressing threat to planetary fine-tuning supporting the multiverse hypothesis is that that hypothesis would have unacceptable epistemological consequences, owing to most individuals with our brain states in the multiverse being skeptically-situated Boltzmann brains—see Collins (2005). Addressing this threat would require an extended discussion that I will not attempt here. Instead, I'll note that I discuss it elsewhere (Saad, 2024b) and that Boltzmann brains also threaten other sources of support for the multiverse hypothesis (not just planetary evidence) and some single-universe hypotheses—see Carroll (2020).

[24] For a unificationist fine-tuning argument in philosophy of mind, see Ross (2017).

[25] Cf. Kitcher (1989) and Halonen and Hintikka (1999).

not fine-tuned and F is to be expected given E.[26] One instance of this schema is a many planets explanation of planetary fine-tuning. Another instance is the multiverse explanation of cosmological fine-tuning. Suppose we accept the former on strength of our planetary evidence. Then adopting the latter—and hence the multiverse hypothesis—would yield a theoretical package that is explanatorily unified through multiple applications of the proposed explanatory schema.[27]

To appreciate the appeal of such explanatory unification, it may help to consider a rival theoretical package on which it is lacking. To that end, consider a rival theoretical package on which (1) God, rather than the multiverse, explains cosmological fine-tuning and (2) an ensemble of planets explains planetary fine-tuning. However exactly the details of this theoretical package are filled in, it will invoke two quite different kinds of explanation to explain two phenomena that seem to invite quite similar explanations. Regardless of whether this theoretical package enjoys compensating virtues, it incurs a cost in giving an explanatorily disunified account of fine-tuning. By the same token, courtesy of our planetary evidence, it is a point in favor of the multiverse hypothesis that it instead leads to a unified explanation of cosmological and planetary fine-tuning.

6 A sup-optimality argument

Here is a sketch of my final argument. A natural reaction to learning that we inhabit a cosmologically fine-tuned universe is to boost one's confidence both in the multiverse hypothesis and in the single-universe hypothesis that a designer created our universe with the (achieved) aim of optimizing it for life, i.e. of making it maximally conducive to life. Subsequently learning from planetary evidence that the universe is not optimized for life supports the multiverse hypothesis over that single-universe hypothesis, as that outcome is to be expected on the former hypothesis and it is incompatible with the latter hypothesis. Plausibly, the multiverse hypothesis suffers no predictive disadvantage with respect to this evidence that is strong enough to cancel its advantage. So, plausibly, learning from our planetary evidence that the universe is not-optimized for life supports the multiverse hypothesis *simpliciter*.

To develop this sketch, I'll continue to focus on optimization for life. However, this is for ease of exposition. It should be borne in mind that the argument could instead be run *mutatis mutandis* in terms of weaker life-favoring biases, some of which may be more plausible conditional on a designer, depending on one's background theological views.

[26] The pattern can be extended to account for the fact that we observe a fine-tuned outcome, given that most of E's outcomes are not fine-tuned, by appealing to an observation selection effect according to which, given that fine-tuning is required for observation and that we're observers, it is to be expected that we would observe one of E's fine-tuned outcomes (and it is unremarkable that we observe F rather than one of E's other fine-tuned outcomes).

[27] One could embrace this theoretical package without having evidence of a planetary ensemble. But such evidence enhances the appeal of the many planets explanation and, in turn, the appeal of the theoretical package's unified account of both forms of fine-tuning.

Let's spell out the argument with a dartboard analogy.[28] To start, we take the dartboard to represent the possible universes within cosmological parameter space. The possible universes that are life-permitting correspond to a small bullseye on the dartboard. In addition, there is a very small bullseye within that bullseye: it represents the possible universes within parameter space that are life-optimized. Whether you will be shown the dartboard depends on whether a dart lands in the life-permitting bullseye. Regardless of how many darts are thrown, you will only be shown the dart that directly enabled you to be shown the dartboard.

You are ignorant of the dart-throwing procedure. But you entertain some possibilities:

- A dart throwing machine will throw (exactly) one dart and aim at a random location on the dartboard.
- A dart throwing entity—perhaps a professional, perhaps a machine—will throw many darts at the dartboard without bias toward a particular region.
- A professional dart thrower will throw one dart and (perfectly) aim at the life-permitting bullseye.
- A professional dart thrower will throw one dart and aim at the life-optimized bullseye.
- A professional dart thrower will throw one dart and aim at the region that is life-permitting but not life-optimized.

It strikes you as very improbable that you will be shown the dartboard conditional on a machine throwing one dart at random. After all, this can be no more likely than that a random location on the dartboard would be in the (small) life-permitting bullseye. It strikes you as at least somewhat probable that you would be shown the dartboard conditional on each of the remaining possibilities. For on each of them it is at least highly probable that a dart will land in the life-permitting bullseye. You also find it more probable that you will be shown a dart outside the (very small) life-optimized bullseye than in it on all but the hypothesis that a professional aimed at the life-optimized bullseye.

You are then shown a dart in the dartboard, albeit at a distance. Because you are being shown the dart, you know that it landed in the life-permitting bullseye. However, from the distance, you can't tell whether the dart landed in the life-optimized bullseye. At this point, you have strong evidence against the hypothesis that a machine randomly threw just a single dart and in favor of the rival hypotheses.[29] You update accordingly.[30]

[28] For other dartboard analogies with fine-tuning, see, e.g., Leslie (1989: Ch. 9).

[29] Proponents of the this-universe will object that you do not have strong evidence in favor of the many-throws hypothesis, as it does not raise the probability of the dart landing at *this* point in the life-permitting bullseye. Per the argument in § 2, I claim this objection is mistaken if it is understood in terms of non-ideal support.

[30] I remain neutral on whether being shown the dartboard at a distance strongly supports the many-throws hypothesis over the single-throw professional dart thrower hypotheses. For reasons that are independent of fine-tuning, your evidence yields such support according to the dart analog of the controversial 'self-indication assumption' that, upon learning that we're observers, we should (other things equal) favor

You then have a closer look at the dartboard. You notice that the dart did not land in the life-optimized bullseye. You then consider how likely the dart was to be in the life-permitting bullseye but not in the life-optimized bullseye on the hypotheses under consideration. You notice that that outcome could not have happened on the single-throw hypothesis that a professional aimed at the life-optimized bullseye. In contrast, the outcome was bound to happen on the single-throw hypothesis that a professional aimed for the region that is life-permitting but not life-optimized. And, since the life-permitting bullseye is much bigger than the life-optimized bullseye, the observed outcome was much more likely than your finding the dart in the life-optimized region on the many-throws hypothesis and on the single-throw hypotheses of a machine randomly throwing a dart and a professional aiming at the life-permitting bullseye. As a result, your second batch of evidence strongly supports the many-throws hypothesis over the single-throw hypothesis that a professional aimed for the life-optimized bullseye; it slightly supports the single-throw hypothesis that a professional aimed at the region that is life-permitting but not life-optimized over the many-throws hypothesis; and it is neutral between the many-throws hypothesis and the remaining single-throw hypotheses.

Of course, the five hypotheses in this scenario correspond to a single universe hypothesis without a designer, the multiverse hypothesis, and the single-universe hypotheses of designers who are either aiming for a life-permitting universe, a life-optimized universe, or a universe that is life-permitting but not life-optimized. In the scenario, discovering that the dart did not land in the life-optimized bullseye provides strong evidence for the many-throws hypothesis over the single-throw hypothesis that a professional aimed for the life-optimizing region.[31] Whether the scenario models our own turns on whether our evidence indicates that our universe is not life-optimized.

In fact, that our universe is not life-optimized is indicated by the discovery of planetary fine-tuning along with the existence of many planets that are not fine-tuned for life. To see this, imagine an alternative course of discovery in which we find out both that our universe is fine-tuned and that there are many planets, all of which are fine-tuned for life. In that case, we would have in effect discovered that the dart landed in the life-optimized bullseye, which would have been strong evidence for the single-universe hypothesis of a life-optimizing designer over the multiverse hypothesis.[32] Having actually found ourselves in a life-permitting rather than a life-optimized uni-

hypotheses that posit more observers over hypotheses that posit relatively few observers (Bostrom, 2002: Chs. 4, 7); cf. Isaacs et al. (2022) and White (2003: 244–245).

[31] It might be thought that there is a crucial disanalogy between the many-throws hypothesis and the multiverse hypothesis: whereas on the many throws hypothesis we should not expect to find a dart in the life-optimized region, on the multiverse hypothesis we should expect to find ourselves in a life-optimized universe, as that's where most observers would be in the multiverse. However, for combinatorial reasons, we should expect the vast majority of observers in the multiverse to be in universes that are not life-optimized. As a toy illustration, suppose for some large numbers p and o that the multiverse consists of the permutations of universes containing p planets, each with o observers or no observers. Then the life-optimized universe will contain p x o observers while the multiverse will contain p x o x $2^{(p-1)}$ observers, meaning only a tiny fraction of all observers—$1/2^{(p-1)}$—reside in the life-optimized universe.

[32] Cf. Benton et al. (2016).

verse, we instead have evidence that supports the multiverse hypothesis over that single-universe hypothesis.

As in the scenario, when we know that we are in a life-permitting universe, learning that we are not in a life-optimized universe does not adjudicate between the multiverse hypothesis and the single-universe hypotheses of randomly selected cosmological parameters and a designer aiming for a life-permitting universe. Relative to those three hypotheses, the single-universe hypothesis of a designer aiming for a universe that is life-permitting but not life-optimized does make it slightly—though only slightly—more likely that the universe would not be life-optimized. Overall, then, learning from our planetary evidence that the universe is not life-optimized strongly supports the multiverse hypothesis relative to one rival and does not strongly disconfirm it relative to the others we have considered.[33] For those of us who do not have strong enough priors in a single-universe hypothesis on which such sub-optimality is even more likely than on the multiverse hypothesis,[34] this evidence supports the multiverse hypothesis *simpliciter*.[35]

7 Conclusion

I have argued that planetary fine-tuning supports the multiverse hypothesis via four routes: strengthening cosmological fine-tuning's support for the multiverse hypothesis by shielding that support from the this-universe objection, enabling cosmological fine-tuning to support the multiverse hypothesis via enumerative induction, enabling the multiverse hypothesis to provide a more unified explanation of fine-tuning, and by pointing to a form of sub-optimality that is distinctively well-predicted by the multiverse hypothesis. These arguments leave open both how confident we should be in the multiverse hypothesis and exactly how much support our planetary evidence lends to that hypothesis. A moral to be drawn is that in order to fully understand the import of fine-tuned laws and initial conditions for the existence of other universes, we must attend to another form of fine-tuning that is closer to home.

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[33] More generally, given the availability of parallel arguments that are couched in terms of weaker life-favoring biases, our planetary evidence of the extent to which our universe is sub-optimal for life strongly supports the multiverse hypothesis over various rival single-universe hypotheses with life-favoring designers.

[34] Such priors will tend to be ruled out by the self-indication assumption—see fn23. (I myself lack such priors irrespective of the self-indication assumption.)

[35] Other arguments in the vicinity that do not appeal to planetary fine-tuning can be found in Monton (2009: 107-8) and Halvorson (2018). My sub-optimality argument also belongs to a broader family of sub-optimality arguments against design hypotheses. Other members of the family include the arguments from evil (see, e.g., Mackie (1955)) and scale (see Everitt (2004: Ch. 11)). For discussion of multiverse defenses of design hypotheses from sub-optimality arguments, see Li & Saad (2024) and references therein.

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References

Acuña, P. (2014). On the empirical equivalence between special relativity and Lorentz's ether theory *Studies in History and Philosophy of Science Part B: Studies in History and. Philosophy of Modern Physics 46*(2):283–302.

Behe, M. J. (2007). *The edge of evolution: The search for the limits of darwinism*. Simon and Schuster.

Benton, M., Hawthorne, J., & Isaacs, Y. (2016). Evil and evidence. *Oxford Studies in Philosophy of Religion*, *7*, 1–31.

Bostrom, N. (2002). *Anthropic bias: Observation selection effects in science and philosophy*. Routledge.

Bradley, D. (2009). Multiple universes and observation selection effects. *American Philosophical Quarterly*, *46*, 61–72.

Bradley, D. (2012). Four problems about self-locating belief. *Philosophical Review*, *121*(2), 149–177.

Carroll, S. M. (2020). Why Boltzmann brains are bad. In S. Dasgupta & B. Weslake (Eds.) In *Current. Controversies in philosophy of science*. Routledge.

Carter, B. (1983). The anthropic principle and its implications for biological evolution. *Philos Trans R Soc Lond A Math Phys Sci*, *310*, 347–363.

Cassan, A., Kubas,… Wyrzykowski, Ł. (2012). One or more bound planets per milky way star from microlensing observations. *Nature*, *481*(7380), 167–169.

Collins, R. (2005). The many-worlds hypothesis as an explanation of cosmic fine-tuning: An alternative to design? *Faith and Philosophy*, *22*(5), 654–666.

Collins, R. (2009). The teleological argument: An exploration of the fine-tuning of the cosmos. In W. L. Craig, & J. P. Moreland (Eds.), *The Blackwell Companion to Natural Theology* (pp. 202–281). Blackwell.

Conselice, C. J., Wilkinson, A., Duncan, K., & Mortlock, A. (2016). The evolution of galaxy number density at $z < 8$ and its implications. *The Astrophysical Journal*, *830*(2), 83.

Cutter, B., & Saad, B. (2023). The problem of Nomological harmony. *Noûs*.

DiPaolo, J. (2019). Second best epistemology: Fallibility and normativity. *Philosophical Studies*, *176*, 82043–82066.

Dowe, P. (1999). Response to holder: Multiple universes are not explanations. *Science & Christian Belief*, *11*, 67–68.

Draper, P. (2020). In defense of the requirement of total evidence. *Philosophy of Science*, *87*(1), 179–190.

Draper, K., Draper, P., & Pust, J. (2007). Probabilistic arguments for multiple universes. *Pacific Philosophical Quarterly*, *88*, 288–307.

Epstein, P. F. (2017). The Fine-Tuning argument and the requirement of total evidence. *Philosophy of Science*, *84*(4), 639–658.

Everitt, N. (2004). *The non-existence of God*. Routledge.

Field, H. (2000). A priority as an evaluative notion. In P. A. Boghossian, & C. Peacocke (Eds.), *New essays on the a priori*. OUP.

Friederich, S. (2019a). Reconsidering the inverse Gambler's fallacy charge against the Fine-Tuning argument for the multiverse. *Journal for General Philosophy of Science, 50*(1)29–41.
Friederich, S. (2019b). A new fine-tuning argument for the multiverse. *Foundations of Physics, 49*(9):1011–1021.
Friederich, S. (2021). *Fine-tuning*. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Winter 2021 Edition). Stanford University. https://plato.stanford.edu/archives/win2021/entries/fine-tuning/
Goff, P. (2021). Is fine-tuning evidence for a multiverse? Manuscript.
Greene, B. (2011). *The hidden reality*. Vintage.
Hacking, I. (1987). The inverse Gambler's fallacy: The argument from design. The anthropic principle applied to Wheeler universes. *Mind*, *96*(383), 331–340.
Halonen, I., & Hintikka, J. (1999). Unification– it's magnificent but is it explanation? *Synthese*, *120*(1), 27–47.
Halvorson, H. (2018). A theological critique of the fine-tuning argument. *Knowledge, belief, and god: New insights in religious epistemology* (pp. 122–135). OUP.
Huemer, M. (2018). *Paradox lost: Logical solutions to ten puzzles of philosophy*. Springer.
Isaacs, Y., Hawthorne, J., & Russell, J. S. (2022). Multiple universes and Self-Locating evidence. *Philosophical Review*
Juhl, C. (2005). Fine-tuning, many worlds, and the 'inverse Gambler's fallacy'. *Noûs*, *39*(2), 337–347.
Kinouchi, O. (2015). The exoplanets analogy to the Multiverse. arXiv preprint arXiv:1506.08060.
Kitcher, P. (1989). Explanatory unification and the causal structure of the world. In P. Kitcher, & W. Salmon (Eds.), *Scientific explanation*. University of Minnesota Press.
Landsman, K. (2016). The fine-tuning argument: Exploring the improbability of our own existence. In K. Landsman, & van E. Wolde (Eds.), *The challenge of chance*. Springer.
Leslie, J. (1989). *Universes*. Routledge.
Lewis, G. F., & Barnes, L. A. (2016). *A fortunate universe: Life in a finely tuned cosmos*. Cambridge University Press.
Li, H., & Saad, B. (2024). The multiverse theodicy Meets population ethics. *Ergo an Open Access Journal of Philosophy*, 10.
Mackie, J. L. (1955). Evil and omnipotence. *Mind*, *64*, 200–212.
Manson, N. A. (2022). Cosmic fine-tuning, the multiverse hypothesis, and the inverse gambler's fallacy. *Philosophy Compass, 17*(9), e12873.
Manson, N. A., & Thrush, M. (2003). Fine-tuning, multiple universes, and the 'this universe' objection. *Pacific Philosophical Quarterly*, *84*, 67–83.
McGrath, P. J. (1988). The inverse Gambler's fallacy and cosmology–a reply to hacking. *Mind*, *97*(386), 265–268.
Monton, B. (2009). *Seeking God in science: An atheist defends intelligent design*. Broadview.
Olding, A. (1990). *Modern biology & natural theology*. Routledge.
Parfit, D. (2011). *On what matters: Vol. 2*. OUP.
Plantinga, A. (2011). *Where the Conflict Really Lies: Science, Religion, & Naturalism*. OUP.
Ross, J. (2017). Idealism and Fine-Tuning. In T. Goldschmidt & K. Pearce (Eds.) *Idealism: New Essays in Metaphysics*.
Saad, B. (2024a). Fine-Tuning should make Us more confident that other universes exist. *American Philosophical Quarterly*.
Saad, B. (2024b). Lessons from the void: what Boltzmann brains teach. *Analytic Philosophy*.
Sandberg, A., Drexler, E., & Ord, T. (2018). Dissolving the Fermi paradox. arXiv preprint arXiv:1806.02404.
Schoenfield, M. (2012). Chilling out on epistemic rationality. *Philosophical Studies*, *158*(2), 197–219.
Smithies, D. (2015). Ideal rationality and logical omniscience. *Synthese*, *192*(9), 2769–2793.
Snyder-Beattie, A. E., Sandberg, A., Drexler, K. E., & Bonsall, M. B. (2021). The timing of evolutionary transitions suggests intelligent life is rare. *Astrobiology*, *21*, 265–278.
Sober, E. (2004). The design argument. In W. E. Mann (Ed.), *The Blackwell Guide to the Philosophy of Religion* (pp. 117–147). Blackwell.
Uson, J. M., Boughn, S. P., & Kuhn, J. R. (1990). The central galaxy in Abell 2029: An old supergiant. *Science*, *250*(4980), 539–540.
Vacca, L. (2025). *Life beyond Earth: The Fermi Paradox— or why we are still waiting to meet aliens*. Springer Nature.
Wallace, A. R. (1904). *Man's Place in the Universe: A Study of the Results of Scientific Research in Relation to the Unity or Plurality of Worlds*. McClure, Phillips & Company.

Ward, P., & Brownlee, D. E. (2000). *Rare Earth: Why complex life is uncommon in the universe*. Copernicus.
White, R. (2000). Fine-tuning and multiple universes. *Noûs*, *34*(2), 260–276.
White, R. (2003). Fine-tuning and multiple universes. In N. A. Manson (Ed.), *God and design: The teleological argument and modern science*. (Chapter 13). Routledge.