Ronald Larson

Design or the Multiverse?

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The effort to explain the "fine-tuning" of our universe by appealing to a "multiverse" of many universes from which our universe is selected for observation by our existence within it, is a double-edged sword. I argue that this line of "anthropic" reasoning implicitly depends on acknowledgment of "apparent design" in the universe, and in principle, in biological evolution as well. Scientists wishing to avoid entanglement of science with religious concepts should consider leaving both "anthropic" reasoning and "design" within the realm of metaphysics, rather than bringing either of them into mainstream physical science.

I n the last couple of decades, physics journals have begun publishing articles containing "anthropic reasoning."[1] Anthropic reasoning attempts to explain why physical constants governing our universe seem to be "fine-tuned" to allow the existence of life. Such reasoning typically presumes the existence of a plethora of universes—collectively known as the "multiverse"—each universe governed by different values of physical constants or even different physical laws. It is then reasoned that the only properties that an "observer" in a universe could ever measure would be those that permit the observer to exist in that universe. Hence, the properties of a universe such as ours only *appear* to be "fine-tuned" to support intelligent life. Huge numbers of other universes with properties that are not fine-tuned also exist, but go unobserved. Arguments such as this have been advanced by Andrei Linde,[2] John Barrow and Frank Tipler,[3] and others. An example described by Garriga et al. involves the density of "dark energy" in the universe, which is governed by the so-called "cosmological constant."[4] The value of this constant appears to be more than a hundred orders of magnitude smaller than what it is expected to be based on quantum mechanics. It has been suggested that anthropic selection may help account for this deviation from what might be expected a priori.

To make anthropic reasoning quantitative (and hence more scientific), one must specify the *a priori* probabilities of the various constants of nature, and the *conditional* probability that intelligent life will emerge which is capable of "observing" a universe characterized by those constants. These probabilities then enter a *Bayesian* inference calculation, which, in principle, might allow one to explain why we observe the physical constants that we do, given the fact that intelligent life must exist within the universe in which the observations are made. (Bayesian inference is a statistical method for adjusting the probability that a particular hypothesis is true by using "new" information that was not used to obtain the initial "a priori" probability. For example, suppose that half the population of the USA vote Democratic and half vote Republican, and that half of the Republicans support a "flat

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tax," but no Democrats do. If I learn that a randomly chosen person in the population does *not* support a flat tax, then I can use Bayesian inference to update the probability of this person being a Democrat from 50% to 66.7%.)

It is worth noting that there are multiple foundational problems that bedevil anthropic reasoning (such as how to define an "observer"[5]) and even if these are overcome, there are good reasons to doubt that the probabilities needed to carry out the Bayesian inferences can ever be made accurate enough to be of value to science. Nevertheless, it is argued that, despite the difficulties, anthropic reasoning involves only material entities and physical laws, and so qualifies as science,[6] albeit at its speculative edge.

Anthropic Reasoning and Design

Anthropic reasoning is controversial among both theistic and atheistic scientists, and raises a host of difficult questions for both camps.[7] Here, I wish to point out the potential that such reasoning has to upset entrenched positions regarding the validity of the notion of "design," both in the laws of physics and in the biological world. Viewed optimistically, perhaps the emergence of anthropic reasoning may offer a way to move toward more constructive interactions among scientists with differing religious and metaphysical perspectives.

Most modern scientists tend to reject the validity of "design" as a principle of science, for one of two reasons. Some atheists, such as Richard Dawkins, believe that science *can* address the possibility of "design" in the universe, and in fact, has already shown that design is absent. Thus, Dawkins' book *The Blind Watchmaker* is subtitled "How the Evidence of Evolution Reveals a Universe without Design."[8] Oddly enough, in accepting design as a topic suitable for scientific inquiry, Dawkins puts himself in the same camp with his archrivals, the intelligent design theorists, who also hold that design can be addressed scientifically, but, *contra* Dawkins, conclude that the universe *does* show evidence of design.[9] Most scientists, however, seem to regard "design" as a concept that science does not, or should not, address.

Anthropic reasoning within science has the potential to upset these entrenched positions, in that

anthropic reasoning accepts that some attributes of our universe appear to be highly improbable, and that science should try to explain this. However, this is a position also taken by advocates of intelligent design.

Thus, I argue here that whoever takes anthropic reasoning to be scientific will have difficulty maintaining the claim that design, or at least *apparent* design, is nonscientific. For example, in a recent book *The Cosmic Landscape,*[10] renowned string theorist Leonard Susskind argues that anthropic reasoning is in the vanguard of physics and cosmology, and he gives his book the provocative subtitle, "The Illusion of Intelligent Design." Note that, if it were somehow possible to demonstrate that there is only one universe, then the "apparent design" (or "illusion of design") addressed by anthropic reasoning would become evidence of *real* design. This could, of course, be avoided by asserting that the existence of the multiverse must be accepted as a *scientific certitude* that no evidence could ever refute. However, in that case, the multiverse would become an untestable concept (not "falsifiable"), and therefore would fail to satisfy an important criterion for a scientific hypothesis. Thus, anthropic reasoning "opens the back door" to design, and there does not seem to be a principled way to boot it back out.

Anthropic Reasoning and Design in Biology

Anthropic reasoning brings the design argument not only back into physics and cosmology, but even back into biology. To see why, we note that the Bayesian calculus used in anthropic reasoning contains *both* the a priori probabilities of various physical constants (putatively derivable from some ultimate physical theory), and the conditional probabilities for the emergence of intelligent life, given those a priori probabilities. Let us initially simplify matters greatly by assuming that we have only one physical constant to explain—call it λ—which we shall assume takes on an improbable value in our universe. To be more concrete, let us assume that the a priori probability distribution for λ is given by a Gaussian:

$$P_\lambda(\lambda) = \frac{1}{\sqrt{2\pi}\sigma_\lambda} \exp\left(-\frac{(\lambda-\lambda_0)^2}{2\sigma_\lambda{}^2}\right) \qquad (1)$$

and that the value of λ that we observe, λ_{obs}, might be far from the a priori most probable value λ_0.

Now let us define the *conditional* probability density $P_e\,(IL\,|\,\lambda)$ for the evolution of intelligent life that is able to make physical measurements in the cosmos (i.e., an "observer"), given a particular value of λ. $IL = 1$ for the presence of an intelligent observer in that universe, and $IL = 0$ for the absence of one. Here, I will ignore the many obstacles to formulating this probability, such as how to decide what constitutes an "observer," how to weight this probability for the number of such "observers" in a given universe, etc. The goal is not to defend such reasoning but only to see its consequences. Let us assume that this function is also a Gaussian in λ, for $IL = 1$; that is,

$$P_e\,(IL = 1\,|\,\lambda) \propto \exp\left(-\frac{(\lambda - \lambda_e)^2}{2\sigma_e^{\,2}}\right) \qquad (2)$$

(We use a proportionality since $P_e\,(IL\,|\,\lambda)$ need not integrate to unity, and its pre-factor is irrelevant in what follows.) Now we ask, what value of λ is most likely to be observed? Conceptually, this can be determined by first generating a large number of universes randomly according to the distribution $P_\lambda(\lambda)$, and then weighting them by the conditional probability density function $P_e\,(IL = 1\,|\,\lambda)$. The probability that an intelligent observer will measure a given value of λ is then the product of these two probabilities:

$$P_{obs}\,(\lambda) = P_e\,(IL = 1\,|\,\lambda)P_\lambda(\lambda).$$

The value of λ most likely to be observed is obtained by maximizing the above product of probabilities by differentiating the product with respect to λ and setting this differential to zero. This yields the most likely observed value λ_{obs}:

$$\frac{\lambda_{obs} - \lambda_e}{\sigma_e^{\,2}} = -\frac{\lambda_{obs} - \lambda_0}{\sigma_\lambda^{\,2}} \text{ or}$$

$$\lambda_{obs} = \left(\lambda_e\sigma_\lambda^{\,2} + \lambda_0\sigma_e^{\,2}\right)/\left(\sigma_\lambda^{\,2} + \sigma_e^{\,2}\right) \qquad (3)$$

Thus, λ_{obs} is a weighted mean of the individual optimal values λ_0 and λ_e of the two functions $P_e\,(IL = 1\,|\,\lambda)$ and $P_\lambda(\lambda)$. The relative weighting given to the values of λ_0 and λ_e is controlled by the inverses of the variances of their respective distributions. The narrower distribution dominates the value of λ_{obs} chosen. If life can evolve almost equally well under a very wide range of values of λ, and the value of λ has a preferred

a priori value, then $\sigma_\lambda^{\,2} \ll \sigma_e^{\,2}$ and λ_{obs} will be close to the a priori most likely value; i.e., it will not be affected much by anthropic considerations. However, if the emergence of intelligent life requires a very precisely tuned value of the physical constant, which would otherwise be free to range over a very wide range of values with nearly equal probability, then $\sigma_e^{\,2} \ll \sigma_\lambda^{\,2}$ and λ_{obs} will be close to the value λ_e, implying that anthropic considerations will dominate the value of λ that is selected.

In some cases, we may observe a value of some property that lies far away from the value of that property that is a priori most likely. An example of this might be the value of the cosmological constant cited earlier. In this case, an anthropic argument would hold that the observed value is pushed away from the a priori most likely value by anthropic considerations. Suppose we observe a value $\lambda = \lambda_{obs}$ that is far out on the tail of the Gaussian distribution function $P_\lambda(\lambda)$. The above equations imply that it is on the opposite side of the distribution function for $P_e\,(IL = 1\,|\,\lambda)$. The explanation for this is straightforward. Anthropic selection explains the improbability of the observed value of λ by arguing that a rare value of this physical parameter is needed for life to evolve. So λ is pushed away from the value that is *a priori* most likely, in order to enhance the *conditional* probability that intelligent life emerges. Since the *a posteriori* probability reflects both of these probabilities, a compromise is struck whereby a lower-than-optimal likelihood for the conditional probability for life to emerge is accepted to keep the a priori probability of a given value of λ from becoming too low. One can show from the above optimization that the probability density for life to emerge in a universe with $\lambda = \lambda_{obs}$ is a factor

$$\exp\left\{-\frac{1}{2}\left[\left(\lambda_0 - \lambda_e\right)/\left[\sigma_\lambda\left(\frac{\sigma_\lambda}{\sigma_e} + \frac{\sigma_e}{\sigma_\lambda}\right)\right]\right]^2\right\}$$

times the probability density under the most favorable conditions for life (i.e., when $\lambda = \lambda_e$). This factor is much less than unity if σ_e is comparable to σ_λ and

$$|\,\lambda_0 - \lambda_e\,| \gg \sigma_\lambda.$$

We can easily extend the argument to a set of several fine-tuned constants $\{\lambda_i\}$, where $i = 1, 2, \ldots N$. If each of these has a Gaussian a priori distribution function and if the conditional probability $P_e\,(IL = 1\,|\,\{\lambda_i\})$ is

a product of Gaussian functions for each λ_i, then optimization with respect to each λ_i yields an equation similar to Eq. 3 for each value of λ_i. The conditional probability $P_e \, (IL = 1 \, | \, \{\lambda_i\})$ will then be a product of Gaussians $P_e \, (IL = 1 \, | \, \lambda_{i,obs})$.

From the foregoing, it follows that intelligent life has a relatively low probability to evolve in the most likely observed universe if even one of the fine-tuned variables has a distribution $P_{e,i} \, (IL = 1 \, | \, \lambda_i)$ whose breadth $\sigma_{i,e}$ is similar to $\sigma_{\lambda,i}$ of the corresponding distribution function $P_{\lambda_i} (\lambda_i)$, and for which the difference between $\lambda_{0,i}$ and $\lambda_{e,i}$ is much greater than either $\sigma_{i,e}$ or $\sigma_{\lambda,i}$. The reason is that, in this case, there is no single value of λ_i that has both a high *a priori* probability and a high *conditional* probability. Thus, the chosen optimal value of λ_i is one that compromises between the degrees of improbability of the two functions. We then must settle for a universe whose constants make intelligent life improbable in any single universe, in order to keep the observed constants of the universe from being even more improbable than they are. This suggests that if the observed constants are improbable ones, then the evolution of intelligent life might be similarly improbable.

Of course, since we have little idea what these probability functions actually are, we can draw only the conclusions that (1) anthropic reasoning entails *the potential* that intelligent life might be extremely improbable in a typical "observable" universe such as ours, and that (2) this probability is entangled with the probability distribution for the constants of the universe. *Thus, if there is "apparent design" in the values of the physical constants, anthropic reasoning leads us to suspect that there might be "apparent design" in biology as well.* This result should not be surprising. Since biology already recognizes natural selection as an explanatory principle, the introduction of a second selection principle, namely anthropic selection, means that there will be a trade-off between the two. Hence, once anthropic reasoning enters science, *natural selection ceases to be the default explanation for biological complexity.* Steps in the evolution from molecules to humans that might have low probabilities for occurrence by natural selection are then candidates for explanation by anthropic reasoning—i.e., they occurred because without them, we would not be here to ponder that fact. These improbable steps would appear to have happened

"by design" rather than by natural selection, just as the physical constants of the universe appear to have values that were chosen "by design." Bayesian calculus is required to adjudicate the relative explanatory roles of natural selection and anthropic selection in biology.

Anthropic Reasoning and Design in Science: Joined at the Hip?

For those who wish to banish the idea of design from science, then, anthropic reasoning is a double-edged sword. While one can always assert that any indications of design are only evidence of *apparent* design, the acceptance of even "apparent design" as a *scientific* principle is a step that has unpleasant implications for some. A hint of this can be seen in a recent writing by science writer Amanda Geffer in the *New Scientist:*

> Discussing the fact that the universe appears fine-tuned for our existence, Weinberg told Dawkins: "If you discovered a really impressive fine-tuning … I think you'd really be left with only two explanations: a benevolent designer or a multiverse."
>
> Weinberg went on to clarify that invoking a benevolent designer does not count as a genuine explanation, but I was intrigued by his either/or scenario. Is that really our only choice? Supernatural creator or parallel worlds? …
>
> But to suggest that if this theory [of the multiverse] doesn't pan out our only other option is a supernatural one is to abandon science itself. Not only is it an unfounded leap of logic, it suggests intelligent design offers as valid an explanation as a cosmological theory does, and lends credence to creationists' mistaken claim that the multiverse was invented to serve as science's get-out-of-God-free card.[11]

For Christians, the increasing popularity of anthropic reasoning within science also raises challenges. There are reasons to believe that the universe is much larger than we can observe, and there are reasons derived from cosmology and string theory to hint that different physical constants might apply in very remote portions of our universe or in other universes. Moreover, there are no definitive scriptural or doctrinal statements that would rule out God creating a vastly larger universe or even parallel universes. Thus, it does not appear to be wise to deny even the

possibility of a multiverse. Yet it seems unwarranted, and likely detrimental to the Christian worldview, to assert dogmatically that evidences of design must be taken only as evidences of *apparent* design and cannot be real design. To do so would be to accept an unscriptural dogma that God is obliged to create an infinity of universes with random properties, rather than just one that he chooses to make with designed properties. Thus, many Christians and other theists are likely to see evidence of "apparent design" as suggestions of at least the possibility of real design, while atheists will resist this inference and find recourse in the multiverse.

Empirical science may not be able to settle this disagreement because both viewpoints—theistic design and anthropic selection—allow infinitely many *potential* universes. In the former viewpoint, our universe is designed by God and the others may not be real, while in the latter, it is the other universes that must be real while the "design" of our universe is only apparent. Since neither God nor the other universes can be observed, it seems doubtful that empirical science can, by itself, decide between these views.

Can't We All Just Get Along (at Least in Science)?

Perhaps a helpful analogy to see a way forward is to consider how the concept of purpose, or teleology, is dealt with by scientists. Even atheists sometimes use language that suggests purpose, as in "the heart's purpose is to pump blood." A prickly Darwinist might insist on restating this as "the heart evolved because by pumping blood it oxygenates tissue more thoroughly, allowing organisms possessing it to survive and propagate their genes more effectively." This clumsy formulation is unneeded, even by the atheist, if he simply re-interprets "purpose" as "apparent purpose." Shorthand references to "purpose" need not offend atheistic scientists who recognize that ultimate reality must be left to metaphysics, not science, to address. If "purpose" is not a scientific concept, but "apparent purpose" can still be recognized in biological organs, then perhaps "design" is also best left as a metaphysical or theological concept, while allowing that the natural world might display "apparent design." In this way, science can construct theories that cope with empirical

or "apparent" realities, while leaving questions of ultimate reality to metaphysics, where the vigorous contest for ultimate truth can continue unabated. Such a pragmatic approach already seems to be followed by nondogmatic scientists when dealing with other ontologies that some materialists consider non-existent, such as objective morality, free will, or personhood.

Such a pragmatic separation of science from metaphysics was advocated by Catholic scientist Pierre Duhem, who wrote

> … to make physical theories depend on metaphysics is surely not the way to let them enjoy the privilege of universal consent … If theoretical physics is subordinated to metaphysics, the divisions separating the diverse metaphysical systems will extend into the domain of physics. A physical theory reputed to be satisfactory by the sectarians of one metaphysical school will be rejected by the partisans of another school.[12]

The metaphysical disputes feared by Duhem are clearly on display in areas of science where evidence of "apparent design" can be found. Attempts by partisans of either camp to obtain decisive victory for their metaphysical position on design in science is likely to lead to continued warfare, not only between theistic and atheistic camps, but even within each of these camps. For all parties, then, a Duhemian approach might be a welcome avenue for maintaining unity within science, while allowing vigorous debate to continue in the arena of metaphysics.   ⮑

Notes

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[9]William A. Dembski, *The Design Inference: Eliminating Chance through Small Probabilities*, Cambridge Studies in Probability, Induction and Decision Theory (Cambridge: Cambridge University Press, 1998).

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[12]Alvin Plantinga, "Methodological Naturalism? Part 2," *Origins & Design* 18, no. 2 (1997). www.arn.org/docs/odesign/od182/methnat182.htm (last accessed November 11, 2010).

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