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Fine-tuned Universe

The **fine-tuned Universe** is the proposition that the conditions that allow life in the Universe can occur only when certain universal dimensionless physical constants lie within a very narrow range of values, so that if any of several fundamental constants were only slightly different, the Universe would be unlikely to be conducive to the establishment and development of matter, astronomical structures, elemental diversity, or life as it is understood.^{[1][2][3][4]}

Various possible explanations of ostensible fine-tuning are discussed among philosophers, scientists, theologians, and proponents and detractors of creationism. The fine-tuned Universe observation is closely related to, but is not exactly synonymous with, the anthropic principle, which is often used as an explanation of apparent fine-tuning.

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History

In 1913, the chemist Lawrence Joseph Henderson (1878–1942) wrote *The Fitness of the Environment*, one of the first books to explore concepts of fine tuning in the Universe. Henderson discusses the importance of water and the environment with respect to living things, pointing out that life depends entirely on the very specific environmental conditions on Earth, especially with regard to the prevalence and properties of water.^[5]

In 1961, physicist Robert H. Dicke claimed that certain forces in physics, such as gravity and electromagnetism, must be perfectly fine-tuned for life to exist anywhere in the Universe.^{[6][7]} Fred Hoyle also argued for a fine-tuned Universe in his 1984 book *Intelligent Universe*. He compares "the chance of obtaining even a single functioning protein by chance combination of amino acids to a star system full of blind men solving Rubik's Cube simultaneously".^[8]

John Gribbin and Martin Rees wrote a detailed history and defence of the fine-tuning argument in their book *Cosmic Coincidences* (1989). According to Gribbin and Rees, "The conditions in our Universe really do seem to be uniquely suitable for life forms like ourselves, and perhaps even for any form of organic complexity. But the question remains - is the Universe tailor-made for man?"^[2]

Premise

The premise of the fine-tuned Universe assertion is that a small change in several of the dimensionless physical constants would make the Universe radically different. As Stephen Hawking has noted, "The laws of science, as we know them at present, contain many fundamental numbers, like the size of the electric charge of the electron and the ratio of the masses of the proton and the electron. ... The remarkable fact is that the values of these numbers seem to have been very finely adjusted to make possible the development of life."^[4]

If, for example, the strong nuclear force were 2% stronger than it is (for example, if the coupling constant representing its strength were 2% larger), while the other constants were left unchanged, diprotons would be stable; according to physicist Paul Davies, hydrogen would fuse into them instead of deuterium and helium.^[9] This would drastically alter the physics of stars, and presumably preclude the existence of life similar to what we observe on Earth. The existence of the diproton would short-circuit the slow fusion of hydrogen into deuterium. Hydrogen would fuse so easily that it is likely that all of the Universe's hydrogen would be consumed in the first few minutes after the Big Bang.^[9] This "diproton argument" is disputed by other physicists, who calculate that as long as the increase in strength is less than 50%, stellar fusion could occur despite the existence of stable diprotons.^[10]

The precise formulation of the idea is made difficult by the fact that physicists do not yet know how many independent physical constants there are. The current standard model of particle physics has 25 freely adjustable parameters with an additional parameter, the cosmological constant, for gravitation. However, because the standard model is not mathematically self-consistent under certain conditions (e.g., at very high energies, at which both quantum mechanics and general relativity are relevant), physicists believe that it is underlaid by some other theory, such as a grand unified theory, string theory, or loop quantum gravity. In some candidate theories, the actual number of independent physical constants may be as small as one. For example, the cosmological constant may be a fundamental constant, but attempts have also been made to calculate it from other constants, and according to the author of one such calculation, "the small value of the cosmological constant is telling us that a remarkably precise and totally unexpected relation exists among all the parameters of the Standard Model of particle physics, the bare cosmological constant and unknown physics."^[11]

Examples

Martin Rees formulates the fine-tuning of the Universe in terms of the following six dimensionless physical constants.^{[1][12]}

- *N*, the ratio of the strength of electromagnetism to the strength of gravity for a pair of protons, is approximately 10^{36} . According to Rees, if it were significantly smaller, only a small and short-lived universe could exist.^[12]

- *Epsilon* (ϵ), a measure of the nuclear efficiency of fusion from hydrogen to helium, is 0.007: when four nucleons fuse into helium, 0.007 (0.7%) of their mass is converted to energy. The value of ϵ is in part determined by the strength of the strong nuclear force.^[13] If ϵ were 0.006, only hydrogen could exist, and complex chemistry would be impossible. According to Rees, if it were above 0.008, no hydrogen would exist, as all the hydrogen would have been fused shortly after the big bang. Other physicists disagree, calculating that substantial hydrogen remains as long as the strong force coupling constant increases by less than about 50%.^{[10][12]}
- *Omega* (Ω), commonly known as the density parameter, is the relative importance of gravity and expansion energy in the Universe. It is the ratio of the mass density of the Universe to the "critical density" and is approximately 1. If gravity were too strong compared with dark energy and the initial metric expansion, the universe would have collapsed before life could have evolved. On the other side, if gravity were too weak, no stars would have formed.^{[12][14]}
- *Lambda* (λ), commonly known as the cosmological constant, describes the ratio of the density of dark energy to the critical energy density of the universe, given certain reasonable assumptions such as positing that dark energy density is a constant. In terms of Planck units, and as a natural dimensionless value, the cosmological constant, λ , is on the order of 10^{-122} .^[15] This is so small that it has no significant effect on cosmic structures that are smaller than a billion light-years across. If the cosmological constant were not extremely small, stars and other astronomical structures would not be able to form.^[12]
- *Q*, the ratio of the gravitational energy required to pull a large galaxy apart to the energy equivalent of its mass, is around 10^{-5} . If it is too small, no stars can form. If it is too large, no stars can survive because the universe is too violent, according to Rees.^[12]
- *D*, the number of spatial dimensions in spacetime, is 3. Rees claims that life could not exist if there were 2 or 4 dimensions of spacetime nor if any other than 1 time dimension existed in spacetime.^[12]

Carbon and oxygen

An older example is the Hoyle state, the third-lowest energy state of the carbon-12 nucleus, with an energy of 7.656 MeV above the ground level. According to one calculation, if the state's energy level was lower than 7.3 or greater than 7.9 MeV, insufficient carbon would exist to support life. Furthermore, to explain the universe's abundance of carbon, the Hoyle state must be further tuned to a value between 7.596 and 7.716 MeV. A similar calculation, focusing on the underlying fundamental constants that give rise to various energy levels, concludes that the strong force must be tuned to a precision of at least 0.5%, and the electromagnetic force to a precision of at least 4%, to prevent either carbon production or oxygen production from dropping significantly.^[16]

Disputes regarding the existence and extent of fine-tuning

Physicist Paul Davies has asserted that "There is now broad agreement among physicists and cosmologists that the universe is in several respects 'fine-tuned' for life". However, he continues, "the conclusion is not so much that the universe is fine-tuned for life; rather it is fine-tuned for the building blocks and environments that life requires." He also states that "'anthropic' reasoning fails to distinguish between minimally biophilic universes, in which life is permitted, but only marginally possible, and optimally biophilic universes, in which life flourishes because abiogenesis occurs frequently".^[17] Among scientists who find the evidence persuasive, a variety of explanations have been proposed, such as the anthropic principle along with multiple universes. George F. R. Ellis states "that no possible astronomical observations can ever see those other universes. The arguments are indirect at best. And even if the multiverse exists, it leaves the deep mysteries of nature unexplained."^[18]

Regarding recently discovered dark energy and its implication on the cosmological constant, Leonard Susskind says "The great mystery is not why there is dark energy. The great mystery is why there is so little of it [10^{-122}]... The fact that we are just on the knife edge of existence, [that] if dark energy were very much bigger we wouldn't be here, that's the mystery." A slightly larger quantity of dark energy, or a slightly larger value of the cosmological constant would have caused space to

expand rapidly enough that galaxies would not form.^[19] Despite this, Susskind does not necessarily see the universe as being fine-tuned, suggesting that some parts of the "megaverse" in which we live might just, by chance, be suitable for the emergence of life, while other parts might not be.^[20]

Steven Weinberg rejects the argument about the fine-tuning of the carbon cycle, arguing that "the fine-tuning of the constants of nature here does not seem so fine". He acknowledges that he currently has no explanation (apart from a multiverse) for the smallness of the cosmological constant, but cautions that "It is still too early to tell whether there is some fundamental principle that can explain why the cosmological constant must be this small."^{[21][22]}

Physicist Victor Stenger objected to the fine-tuning, and especially to theist use of fine-tuning arguments. His numerous criticisms included what he called "the wholly unwarranted assumption that only carbon-based life is possible."^[23] In turn, the astrophysicist Luke Barnes has criticised much of Stenger's work.^[24]

The validity of fine tuning examples is sometimes questioned on the grounds that such reasoning is subjective anthropomorphism applied to natural physical constants. Critics also suggest that the fine-tuned Universe assertion and the anthropic principle are essentially tautologies.^[25]

The fine-tuned Universe argument has also been criticized as an argument by lack of imagination, as it assumes no other forms of life, sometimes referred to as carbon chauvinism. Conceptually, alternative biochemistry or other forms of life are possible.^[26] Regarding this, Stenger argued: "We have no reason to believe that our kind of carbon-based life is all that is possible. Furthermore, modern cosmology theorises that multiple universes may exist with different constants and laws of physics. So, it is not surprising that we live in the one suited for us. The universe is not fine-tuned to life; life is fine-tuned to the universe."^[27]

In addition, critics argue that humans are adapted to the Universe through the process of evolution, rather than the Universe being adapted to humans (see puddle thinking, below). They also see it as an example of the logical flaw of hubris or anthropocentrism in its assertion that humans are the purpose of the Universe.^[28]

Possible naturalistic explanations

There are fine tuning arguments that are naturalistic.^[29] As modern cosmology developed, various hypotheses have been proposed. One is an oscillatory universe or a multiverse, where fundamental physical constants are postulated to resolve themselves to random values in different iterations of reality.^[30] Under this hypothesis, separate parts of reality would have wildly different characteristics. In such scenarios, the appearance of fine-tuning is explained as a consequence of the weak anthropic principle and selection bias (specifically survivor bias) that only those universes with fundamental constants hospitable to life (such as the universe we observe) would have living beings emerge and evolve capable of contemplating the questions of origins and of fine-tuning. All other universes would go utterly unhehld by any such beings.

Multiverse

The Multiverse hypothesis proposes the existence of many universes with different physical constants, some of which are hospitable to intelligent life (see multiverse: anthropic principle). Because we are intelligent beings, it is unsurprising that we find ourselves in a hospitable universe if there is such a multiverse. The Multiverse hypothesis is therefore thought to provide an elegant explanation of the finding that we exist despite the required fine-tuning. (See ^[31] for a detailed discussion of the arguments for and against this suggested explanation.)

The multiverse idea has led to considerable research into the anthropic principle and has been of particular interest to particle physicists, because theories of everything do apparently generate large numbers of universes in which the physical constants vary widely. As yet, there is no evidence for the existence of a multiverse, but some versions of the theory do make predictions that some researchers studying M-theory and gravity leaks hope to see some evidence of soon.^[32] Some multiverse theories are not falsifiable, thus scientists may be reluctant to call any multiverse theory "scientific". UNC-Chapel Hill professor Laura Mersini-Houghton claims that the WMAP cold spot may provide testable empirical evidence for a parallel universe,^[33] although this claim was recently refuted as the WMAP cold spot was found to be nothing more than a statistical artifact.^[34] Variants on this approach include Lee Smolin's notion of cosmological natural selection, the Ekpyrotic universe, and the Bubble universe theory.

Critics of the multiverse-related explanations argue that there is no independent evidence that other universes exist. Some criticize the inference from fine-tuning for life to a multiverse as fallacious,^[35] whereas others defend it against that challenge.^[36]

Top-down cosmology

Stephen Hawking, along with Thomas Hertog of CERN, proposed that the Universe's initial conditions consisted of a superposition of many possible initial conditions, only a small fraction of which contributed to the conditions we see today.^[37] According to their theory, it is inevitable that we find our Universe's "fine-tuned" physical constants, as the current Universe "selects" only those past histories that led to the present conditions. In this way, top-down cosmology provides an anthropic explanation for why we find ourselves in a universe that allows matter and life, without invoking the ontic existence of the Multiverse.^[38]

Alien design

One hypothesis is that the Universe may have been designed by extra-universal aliens. Some believe this would solve the problem of how a designer or design team capable of fine-tuning the Universe could come to exist. Cosmologist Alan Guth believes humans will in time be able to generate new universes.^[39] By implication previous intelligent entities may have generated our Universe.^[40] This idea leads to the possibility that the extraterrestrial designer/designers are themselves the product of an evolutionary process in their own universe, which must therefore itself be able to sustain life. However it also raises the question of where that universe came from, leading to an infinite regress.

The Designer Universe theory of John Gribbin suggests that the Universe could have been made deliberately by an advanced civilization in another part of the Multiverse, and that this civilization may have been responsible for causing the Big Bang.^[41]

Philosophical arguments

As with theistic evolution, some individual scientists, theologians, and philosophers as well as certain religious groups argue that providence or creation are responsible for fine-tuning.

Philosopher Alvin Plantinga argues that random chance, applied to a single and sole universe, only raises the question as to why this universe could be so "lucky" as to have precise conditions that support life at least at some place (the Earth) and time (within millions of years of the present).

One reaction to these apparent enormous coincidences is to see them as substantiating the theistic claim that the universe has been created by a personal God and as offering the material for a properly restrained theistic argument—hence the fine-tuning argument. It's as if there are a large number of dials that have to be tuned to within extremely narrow limits for life to be possible in our universe. It is extremely unlikely that this should happen by chance, but much more likely that this should happen, if there is such a person as God.

— Alvin Plantinga, *The Dawkins Confusion; Naturalism ad absurdum*^[42]

This fine-tuning of the Universe is cited^[43] by philosopher and Christian apologist William Lane Craig as an evidence for the existence of God or some form of intelligence capable of manipulating (or designing) the basic physics that governs the Universe. Craig argues, however, "that the postulate of a divine Designer does not settle for us the religious question."

Philosopher and theologian Richard Swinburne reaches the design conclusion using Bayesian probability.^[44]

Theologian Alister McGrath has pointed out that the fine-tuning of carbon is even responsible for nature's ability to tune itself to any degree.

[The entire biological] evolutionary process depends upon the unusual chemistry of carbon, which allows it to bond to itself, as well as other elements, creating highly complex molecules that are stable over prevailing terrestrial temperatures, and are capable of conveying genetic information (especially DNA). [...] Whereas it might be argued that nature creates its own fine-tuning, this can only be done if the primordial constituents of the universe are such that an evolutionary process can be initiated. The unique chemistry of carbon is the ultimate foundation of the capacity of nature to tune itself.^{[45][46]}

Theoretical physicist John Polkinghorne has stated: Anthropic fine tuning is too remarkable to be dismissed as just a happy accident.^[47]

Intelligent design

Proponents of Intelligent design argue that certain features of the Universe and of living things are best explained by an intelligent cause, not an undirected process such as natural selection. The fine-tuned Universe argument is a central premise or presented as given in many of the published works of prominent intelligent design proponents, such as William A. Dembski and Michael Behe.

Counterarguments

Mark Colyvan, Jay Garfield and Graham Priest (2005) have argued that a theistic explanation for fine tuning is faulted due to fallacious probabilistic reasoning.^[48]

Mathematician Michael Ikeda and astronomer William H. Jefferys have argued that the anthropic principle and selection effect are not properly taken into account in the fine tuning argument for a designer, and that in taking them into account, fine tuning does not support the designer hypothesis.^{[49][50]} Philosopher of science Elliott Sober makes a similar argument.^[51]

Physicist Robert L. Park has also criticized the theistic interpretation of fine-tuning:

If the universe was designed for life, it must be said that it is a shockingly inefficient design. There are vast reaches of the universe in which life as we know it is clearly impossible: gravitational forces would be crushing, or radiation levels are too high for complex molecules to exist, or temperatures would make the formation of stable chemical bonds impossible... Fine-tuned for life? It would make more sense to ask why God designed a universe so inhospitable to life.^[52]

Victor Stenger argues that "The fine-tuning argument and other recent intelligent design arguments are modern versions of God-of-the-gaps reasoning, where a God is deemed necessary whenever science has not fully explained some phenomenon".^[23] Stenger argues that science may provide an explanation if a Theory of Everything is formulated, which he says may reveal connections between the physical constants. A change in one physical constant may be compensated by a change in another, suggesting that the apparent fine-tuning of the universe is a fallacy because, in hypothesizing the apparent fine-tuning, it is mistaken to vary one physical parameter while keeping the others constant.^[53]

In popular culture

- *Puddle theory* is a term coined by Douglas Adams to satirize arguments that the universe is made for man.^{[54][55]} As stated in Adams's book *The Salmon of Doubt*.^[56]

imagine a puddle waking up one morning and thinking, "This is an interesting world I find myself in, an interesting hole I find myself in, fits me rather neatly, doesn't it? In fact, it fits me staggeringly well, must have been made to have me in it!" This is such a powerful idea that as the sun rises in the sky and the air heats up and as, gradually, the puddle gets smaller and smaller, it's still frantically hanging on to the notion that everything's going to be all right, because this World was meant to have him in it, was built to have him in it; so the moment he disappears catches him rather by surprise. I think this may be something we need to be on the watch out for.

- Carl Sagan's novel *Contact* ends with the protagonist learning that a makers' mark is found whenever the application of math to the Universe is correct.

See also

- Abiogenesis
- Clockwork universe
- Fine-tuning
- Rare Earth hypothesis
- Teleology
- Ultimate fate of the universe
- Weakless universe

References

1. Rees, Martin (May 3, 2001). *Just Six Numbers: The Deep Forces That Shape The Universe*. New York, NY: Basic Books; First American edition. p. 4.
2. Gribbin. J and Rees. M, *Cosmic Coincidences: Dark Matter, Mankind, and Anthropic Cosmology* p. 7, 269, 1989, ISBN 0-553-34740-3

3. Davis, Paul (2007). *Cosmic Jackpot: Why Our Universe Is Just Right for Life*. New York, NY: Orion Publications. p. 2. ISBN 0618592261.
4. Stephen Hawking, 1988. *A Brief History of Time*, Bantam Books, ISBN 0-553-05340-X, p. 7, 125.
5. Lawrence Joseph Henderson, *The fitness of the environment: an inquiry into the biological significance of the properties of matter* The Macmillan Company, 1913
6. R. H. Dicke (1961). "Dirac's Cosmology and Mach's Principle". *Nature*. **192** (4801): 440–441. Bibcode:1961Natur.192..440D (<http://adsabs.harvard.edu/abs/1961Natur.192..440D>). doi:10.1038/192440a0 (<https://doi.org/10.1038%2F192440a0>).
7. Heilbron, J. L. *The Oxford guide to the history of physics and astronomy, Volume 10* 2005, p. 8
8. Profile of Fred Hoyle at OPT (<http://www.optcorp.com/edu/articleDetailEDU.aspx?aid=1530>) Archived (<https://web.archive.org/web/20120406200054/http://www.optcorp.com/edu/articleDetailEDU.aspx?aid=1530>) 2012-04-06 at the Wayback Machine. Optcorp.com. Retrieved on 2013-03-11.
9. Paul Davies, 1993. *The Accidental Universe*, Cambridge University Press, p70-71
10. MacDonald, J.; Mullan, D. J. (2009). "Big bang nucleosynthesis: The strong nuclear force meets the weak anthropic principle". *Physical Review D*. **80** (4): 043507. arXiv:0904.1807 (<https://arxiv.org/abs/0904.1807>) . Bibcode:2009PhRvD..80d3507M (<http://adsabs.harvard.edu/abs/2009PhRvD..80d3507M>). doi:10.1103/physrevd.80.043507 (<https://doi.org/10.1103%2Fphysrevd.80.043507>). "Contrary to a common argument that a small increase in the strength of the strong force would lead to destruction of all hydrogen in the big bang due to binding of the diproton and the dineutron with a catastrophic impact on life as we know it, we show that provided the increase in strong force coupling constant is less than about 50% substantial amounts of hydrogen remain."
11. Abbott, Larry (1991). "The Mystery of the Cosmological Constant". *Scientific American*. **3** (1): 78.
12. Lemley, Brad. "Why is There Life?" (<http://discovermagazine.com/2000/nov/cover/>). *Discover magazine*. Retrieved 23 August 2014.
13. Morison, Ian (2013). "9.14: A universe fit for intelligent life". *Introduction to astronomy and cosmology*. Hoboken, N.J.: Wiley. ISBN 9781118681527.
14. Sean Carroll and Michio Kaku (2014). *How the Universe Works 3*. End of the Universe. Discovery Channel.
15. John D. Barrow The Value of the Cosmological Constant (<https://arxiv.org/abs/1105.3105>)
16. Livio, M.; Hollowell, D.; Weiss, A.; Truran, J. W. (27 July 1989). "The anthropic significance of the existence of an excited state of ¹²C". *Nature*. **340** (6231): 281–284. Bibcode:1989Natur.340..281L (<http://adsabs.harvard.edu/abs/1989Natur.340..281L>). doi:10.1038/340281a0 (<https://doi.org/10.1038%2F340281a0>).
17. Davies (2003). "How bio-friendly is the universe". *Int.J.Astrobiol.* **2** (115): 115. arXiv:astro-ph/0403050 (<https://arxiv.org/abs/astro-ph/0403050>) . Bibcode:2003IJAsB...2..115D (<http://adsabs.harvard.edu/abs/2003IJAsB...2..115D>). doi:10.1017/S1473550403001514 (<https://doi.org/10.1017%2FS1473550403001514>).
18. George F. R. Ellis, "Does the Multiverse Really Exist?" (<http://www.scientificamerican.com/article.cfm?id=does-the-multiverse-really-exist>) *Scientific American*
19. Ananthaswamy, Anil. "Is the Universe Fine-Tuned for Life?" (<https://www.pbs.org/wgbh/nova/blogs/physics/2012/03/is-the-universe-fine-tuned-for-life/>). Public Broadcasting Service (PBS).
20. Ross, Greg (2015). "An interview with Leonard Susskind" (<http://www.americanscientist.org/bookshelf/pub/leonard-susskind>). *American Scientist*.
21. Weinberg, Steven (1999). "A Designer Universe?" (http://www.physlink.com/Education/essay_weinberg.cfm). physlink.com.
22. "Interview" (<https://www.pbs.org/faithandreason/transcript/wein-frame.html>). Public Broadcasting System, pbs.org.
23. Stenger, Victor J. "Is The Universe Fine-Tuned For Us?" (<https://web.archive.org/web/20120716192004/http://www.colorado.edu/philosophy/vstenger/Cosmo/FineTune.pdf#search=%22Fine%20tuned%20universe%22>) (PDF). University of Colorado. Archived from the original (<http://www.colorado.edu/philosophy/vstenger/Cosmo/FineTune.pdf#search=%22Fine%20tuned%20universe%22>) (PDF) on 2012-07-16.

24. Barnes (2011). "The Fine-Tuning of the Universe for Intelligent Life". *Publications of the Astronomical Society of Australia*. **29**: 529–564. arXiv:1112.4647 (<https://arxiv.org/abs/1112.4647>) [physics.hist-ph (<https://arxiv.org/archive/physics.hist-ph>)]. Bibcode:2012PASA...29..529B (<http://adsabs.harvard.edu/abs/2012PASA...29..529B>). doi:10.1071/AS12015 (<https://doi.org/10.1071%2FAS12015>).
25. See, e.g., [Silk, Joseph](#) (September 14, 2006). "Our place in the Multiverse" (<http://www.nature.com/nature/journal/v443/n7108/full/443145a.html>). *Nature*. **443** (7108): 145–146. Bibcode:2006Natur.443..145S (<http://adsabs.harvard.edu/abs/2006Natur.443..145S>). doi:10.1038/443145a (<https://doi.org/10.1038%2F443145a>).
26. See, e.g. Jack Cohen and Ian Stewart: *What Does a Martian Look Like: The Science of Extraterrestrial Life*, Wiley, 2002, p. 159.
27. [Stenger, Victor J.](#) "Flew's Flawed Science" (<http://www.mukto-mona.com/Articles/vstenger/flew.htm>).
28. See, e.g., Gerald Feinberg and Robert Shapiro, "A Puddlian Fable" in Huchingson, *Religion and the Natural Sciences* (1993), pp. 220–221
29. L. Susskind, *The cosmic landscape: string theory and the illusion of intelligent design*. (Little, Brown, 2005)
30. Wheeler, J. A. (1977) in *Foundational problems in the special sciences*, Reidel, Dordrecht, pp 3–33
31. Friederich, Simon (2017). Zalta, Edward N., ed. *The Stanford Encyclopedia of Philosophy* (<https://plato.stanford.edu/archives/fall2017/entries/fine-tuning/>) (Fall 2017 ed.). Metaphysics Research Lab, Stanford University.
32. *Parallel Worlds*, 2005, [Michio Kaku](#), pp. 220–221
33. "Two Programmes – Horizon, 2010–2011, What Happened Before the Big Bang?" (<http://www.bbc.co.uk/programmes/b00vdkmj>). BBC. Retrieved 2011-01-02.
34. Zhang, Ray; Dragan Hunterer (1970). "Disks in the sky: A reassessment of the WMAP "cold spot" ". *Astroparticle Physics*. **33** (69 (2010)): 69. arXiv:0908.3988v2 (<https://arxiv.org/abs/0908.3988v2>) Bibcode:2010APh....33...69Z (<http://adsabs.harvard.edu/abs/2010APh....33...69Z>). doi:10.1016/j.astropartphys.2009.11.005 (<https://doi.org/10.1016%2Fj.astropartphys.2009.11.005>).
35. White, Roger (2000-06-01). "Fine-Tuning and Multiple Universes" (<http://onlinelibrary.wiley.com/doi/10.1111/0029-4624.00210/abstract>). *Noûs*. **34** (2): 260–276. doi:10.1111/0029-4624.00210 (<https://doi.org/10.1111%2F0029-4624.00210>). ISSN 1468-0068 (<https://www.worldcat.org/issn/1468-0068>).
36. Bradley, Darren (2009). "Multiple Universes and Observation Selection Effects". *American Philosophical Quarterly*. **46** (1): 61–72. doi:10.2307/20464437 (<https://doi.org/10.2307%2F20464437>). JSTOR 20464437 (<https://www.jstor.org/stable/20464437>).
37. Ball, Philip (June 21, 2006). "Hawking Rewrites History...Backwards" (<http://www.nature.com/news/2006/060619/full/news060619-6.html>). *Nature News Online*. Retrieved April 19, 2010.
38. [Hawking, S. W.](#); Hertog, Thomas (February 2006). "Populating the Landscape: A Top Down Approach" (<https://arxiv.org/pdf/hep-th/0602091v2.pdf>) (PDF). *Phys. Rev.* **D73** (12): 123527. arXiv:hep-th/0602091v2 (<https://arxiv.org/abs/hep-th/0602091v2>) Bibcode:2006PhRvD..73I3527H (<http://adsabs.harvard.edu/abs/2006PhRvD..73I3527H>). doi:10.1103/PhysRevD.73.123527 (<https://doi.org/10.1103%2FPhysRevD.73.123527>). Retrieved June 15, 2012.
39. Malcolm W. Browne (1987-04-14). "Physicist Aims to Create a Universe, Literally" (<https://www.nytimes.com/1987/04/14/science/physicist-aims-to-create-a-universe-literally.html?pagewanted=all>). *New York Times*. Retrieved 2015-10-17.
40. *Science & Nature – Horizon – Parallel Universes – Transcript* (<http://www.bbc.co.uk/science/horizon/2001/paralleluniverses.shtml>). BBC (2002-02-14). Retrieved on 2013-03-11.
41. John Gribbin, *In Search of the Multiverse: Parallel Worlds, Hidden Dimensions, and the Ultimate Quest for the Frontiers of Reality*, 2010, p. 195
42. Alvin Plantinga, "The Dawkins Confusion; Naturalism ad absurdum," (<http://www.philvaz.com/apologetics/DawkinsGodDelusionPlantingaReview.pdf>) *Christianity Today*, March/April 2007
43. William Lane Craig, "The Teleological Argument and the Anthropic Principle" (<http://www.leaderu.com/offices/billcraig/docs/teleo.html>). leaderu.com

44. Richard Swinburne, 1990. *Argument from the fine-tuning of the Universe*, in Physical cosmology and philosophy, J. Leslie, Editor. Collier Macmillan: New York. pp. 154–73.
45. McGrath, Alister E. (2009). *A fine-tuned universe : the quest for God in science and theology* (1st ed.). Louisville, KY.: Westminster John Knox Press. p. 176. ISBN 0664233104.
46. "What is the "fine-tuning" of the universe, and how does it serve as a "pointer to God"?" (<https://web.archive.org/web/20141221081439/http://biologos.org/questions/fine-tuning>). *BioLogos.org*. Archived from the original (<http://biologos.org/questions/fine-tuning>) on 2014-12-21.
47. Polkinghorne, John (1998) *Science and Theology: An Introduction* p. 75
48. Colyvan *et al.* (2005). *Problems with the Argument from Fine Tuning* (<http://www.colyvan.com/papers/finetuning.pdf>). *Synthese* 145: 325-38.
49. The Anthropic Principle Does Not Support Supernaturalism (<http://quasar.as.utexas.edu/anthropic.html>), Michael Ikeda, Bill Jefferys
50. Michael Ikeda and William H. Jefferys, "The Anthropic Principle Does Not Support Supernaturalism," in *The Improbability of God*, Michael Martin and Ricki Monnier, Editors, pp. 150–166. Amherst, N.Y.: Prometheus Press. ISBN 1-59102-381-5.
51. Elliott Sober, 2004. *The Design Argument*, in *The Blackwell Guide to the Philosophy of Religion*, W. E. Mann, Editor. Blackwell Publishing, ISBN 0-631-22129-8.
52. Park, Robert L. (2009). *Superstition: Belief in the Age of Science*. Princeton University Press. p. 11. ISBN 978-0-691-13355-3
53. Chown, Marcus (14 June 2011). "Why the universe wasn't fine-tuned for life" (<https://www.newscientist.com/blogs/culturelab/2011/06/why-the-universe-wasnt-fine-tuned-for-life.html>). *New Scientist*.
54. Williams, Robyn (18 February 2006). "The anthropic universe" (<http://www.abc.net.au/rn/scienceshow/stories/2006/1572643.htm>). *The Science Show*. ABC Radio National. Retrieved 19 November 2009.
55. Redfern, Martin (24 December 1995). "Proofs of God in a photon" (<https://www.independent.co.uk/arts-entertainment/proofs-of-god-in-a-photon-1527306.html>). *The Independent*. Retrieved 19 November 2009.
56. Adams, Douglas (2002). *The Salmon of Doubt: Hitchhiking the Galaxy One Last Time* (<https://books.google.com/books?id=pDchCdg9K-8C&q=imagine+a+puddle#v=snippet&q=imagine%20a%20puddle&f=false>). Harmony Books. p. 131. Retrieved January 9, 2015.

Further reading

- Barrow, John D.; Tipler, Frank J. (1988). *The Anthropic Cosmological Principle*. Oxford University Press. ISBN 978-0-19-282147-8. LCCN 87028148 (<https://lccn.loc.gov/87028148>).
- John D. Barrow, 2003. *The Constants of Nature*, Pantheon Books, ISBN 0-375-42221-8
- Bernard Carr, ed. (2007) *Universe or Multiverse?* Cambridge University Press.
- Mark Colyvan, Jay Garfield, Graham Priest. (2005). *Problems with the Argument from Fine Tuning* (<http://www.colyvan.com/papers/finetuning.pdf>). *Synthese* 145: 325-38.
- Paul Davies, 1982. *The Accidental Universe*, Cambridge University Press, ISBN 0-521-24212-6
- Paul Davies, 2007. *Cosmic Jackpot: Why Our Universe Is Just Right for Life*, Houghton Mifflin Harcourt, ISBN 0-618-59226-1. Reprinted as: *The Goldilocks Enigma: Why Is the Universe Just Right for Life?*, 2008, Mariner Books, ISBN 0-547-05358-4.
- Geraint F. Lewis and Luke A. Barnes, 2016. *A Fortunate Universe: Life in a finely tuned cosmos*, Cambridge University Press. ISBN 1107156610
- Alister McGrath, 2009. *A Fine-Tuned Universe: The Quest for God in Science and Theology*, Westminster John Knox Press, ISBN 0-664-23310-4.
- Timothy McGrew, Lydia McGrew, Eric Vestrup, 2001. *Probabilities and the Fine-Tuning Argument: A Sceptical View*. *Mind* 110: 1027-1037.
- Simon Conway Morris, 2003. *Life's Solution: Inevitable Humans in a Lonely Universe*. Cambridge Univ. Press.
- Martin Rees, 1999. *Just Six Numbers*, HarperCollins Publishers, ISBN 0-465-03672-4.

- Victor J. Stenger, 2011. *The Fallacy of Fine-Tuning: Why the Universe Is Not Designed for Us*. Prometheus Books. ISBN 978-1-61614-443-2.
- Peter Ward and Donald Brownlee, 2000. *Rare Earth: Why Complex Life is Uncommon in the Universe*. Springer Verlag.

External links

Defend fine-tuning

- Anil Ananthaswamy: Is the Universe Fine-tuned for Life? (<https://www.pbs.org/wgbh/nova/blogs/physics/2012/03/is-the-universe-fine-tuned-for-life/>)
- Francis Collins, Why I'm a man of science-and faith (<http://news.nationalgeographic.com/2015/03/150319-three-questions-francis-collins-nih-science/>). *National Geographic* article.
- *Custom Universe* (<http://www.abc.net.au/catalyst/customuniverse/default.htm>), Documentary of fine-tuning with scientific experts.
- Mawson, T. J. (2011). "Explaining the fine tuning of the universe to us and the fine tuning of us to the universe" (<http://ora.ox.ac.uk/objects/uuid:26d2f182-e4f1-44ee-954b-d519fd375565>). *Philosophy*. **68**: 25–50. doi:10.1017/s1358246111000075 (<https://doi.org/10.1017%2Fs1358246111000075>).
- Hugh Ross: Evidence for the Fine Tuning of the Universe (<https://www.ualberta.ca/~dlamour/h15.pdf>)
- Interview (http://www.berkeley.edu/news/media/releases/2005/06/17_townes.shtml) with Charles Townes discussing science and religion.

Criticize fine tuning

- Bibliography of online Links to criticisms of the Fine-Tuning Argument. (<http://www.infidels.org/library/modern/theism/design.html#fine>) Secular Web.
- Victor Stenger:
 - "A Case Against the Fine-Tuning of the Cosmos (<https://web.archive.org/web/20150605024914/http://www.colorado.edu/philosophy/vstenger/Fallacy/FTCosmo.pdf>)"
 - "Does the Cosmos Show Evidence of Purpose? (<https://web.archive.org/web/20051205085645/http://www.colorado.edu/philosophy/vstenger/Cosmo/anthro.skinq.html>)"
 - "Is the Universe fine-tuned for us? (<https://web.archive.org/web/20120716192004/http://www.colorado.edu/philosophy/vstenger/Cosmo/FineTune.pdf>)"
- Elliott Sober, "The Design Argument. (<http://philosophy.wisc.edu/sober/design%20argument%2011%202004.pdf>)" An earlier version appeared in the *Blackwell Companion to the Philosophy of Religion* (2004).

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