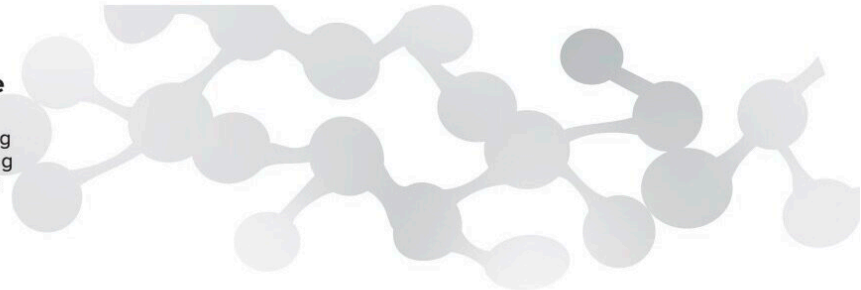


Is the 'fine-tuned universe' an illusion?

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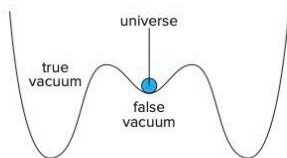
The Inflationary Multiverse

Inflation may start and end at different times and places, creating a multiverse of parallel neighboring cosmoses. String theory suggests these universes may have different properties, laws and even dimensions.



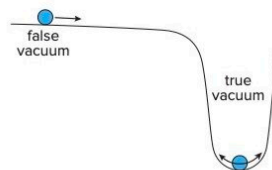
Old Inflation

(a) While the universe is nestled in the higher-energy 'false vacuum' state, it inflates, expanding at an exponential rate. Inflation only ends when the universe is in the true vacuum. But how can it reach there?



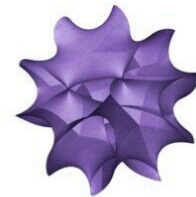
New 'Slow-Roll' Inflation

(b) The false vacuum is represented by a shallow incline. As the universe slowly rolls down, it continues to inflate. Inflation ends when it hits the true vacuum, rolling back and forth in the valley, releasing energy to create new particles.



Extra Dimensions

(c) String theory predicts there are a number of extra dimensions, hidden from us because they are small and curled up in complex ways. The image shows a 2-dimensional slice of one such proposed 6-dimensional folding pattern.



A multiverse of multiple parallel universes, each with different physical parameters, is predicted to exist by some cosmological inflation models, combined with string theory. The multiverse provides one explanation to the fine-tuning problem of why our cosmos seems to have just the right parameters to harbor intelligent life. Credit: Created by Maayan Harel for the Foundational Questions Institute, FQXi.

For decades physicists have been perplexed about why our cosmos appears to have been precisely tuned to foster intelligent life. It is widely thought that if the values of certain physical parameters, such as the masses of elementary particles, were tweaked, even slightly, it would have prevented the formation of the components necessary for life in the universe—including planets, stars, and galaxies. But recent studies, detailed in a new report by the Foundational Questions Institute, FQXi, propose that intelligent life could have evolved under drastically different physical conditions. The claim undermines a major argument in support of the existence of a multiverse of parallel universes.

"The tuning required for some of these physical parameters to give rise to life turns out to be less precise than the tuning needed to capture a station on your radio, according to new calculations," says Miriam Frankel, who authored the FQXi report, which was produced with support from the John Templeton Foundation. "If true, the apparent fine tuning may be an illusion," Frankel adds.

Over the last few decades, the subject of fine tuning has attracted some of the sharpest minds in physics. By probing the [universe](#)'s physical laws and precisely pinning down the values of physical constants—such as the masses of elementary particles and the strengths of forces—physicists have discovered that surprisingly small variations in these values would have rendered the universe lifeless. This led to a puzzle: why are physical conditions seemingly tailored towards human existence?

Some physicists have explained away these serendipitous conditions by invoking multiverse theory, which states that there are an infinite number of [parallel universes](#), each with different physical parameters. Within the multiverse framework, it is not so surprising that humans should have evolved in one of the parallel realities in which conditions happen to be habitable for us. So the fine-tuning puzzle evaporates.

But other scientists have remained skeptical that our universe is fine tuned for life, at all. In FQXi's in-depth report, Frankel explores the complex history of research on fine tuning, including potential explanations for it—such as those derived from string theory and the multiverse framework—and assesses proposals for experimentally testing these explanations directly and indirectly. The report then outlines arguments that fine-tuning is an illusion, noting that life may take a very different form than naively imagined, and that if multiple physical parameters are considered to vary simultaneously, it could alleviate any apparent fine-tuning problems. This suggests that the universe may not be so finely tuned; it may be able to produce life under a much wider range of circumstances than first thought.

Fred Adams, an astrophysicist and expert on fine tuning at the University of Michigan, in Ann Arbor, says that "the developments outlined in this report emphasize that the fine-tuning problem is more nuanced than has been discussed previously, with wider allowed ranges for the relevant physical parameters." For instance, it has often been stated that even subtly changing the balance of the forces that govern the atomic nucleus, or the values of fundamental constants of nature, could affect the formation of carbon in stars—needed for the development of organic life—or affect the lifetimes of stars, thus preventing them from providing enough energy for habitable planets to exist. But the equations of stellar structure may have more solutions than most people realize. "Stars can continue to operate with substantial variations in the fundamental constants," says Adams, whose work is featured in the report. "Moreover, if a particular astrophysical process becomes inoperable, then (often) another process can take its place to help provide energy for the universe."

"Claims of fine tuning have long split opinions," says FQXi's scientific program manager David Sloan, a physicist at the University of Lancaster, UK, who edited the book *Fine-Tuning in the Physical*

Universe, published by Cambridge University Press in 2020. "When parameters required for life seem to turn up in suspiciously narrow regions we seek explanations of this as either coincidence or cosmic conspiracy. Finding that these regions could be broader, or that other life-permitting regions exist, weakens the need for such explanations. It could be that there is no conspiracy at all," says Sloan, whose research is also featured in the [report](#).

More information: Report: [www.templeton.org/wp-content/u ...
uning-research-1.pdf](http://www.templeton.org/wp-content/uploads/2022/02/fine-tuned-universe-illusion-research-1.pdf)

Provided by Foundational Questions Institute, FQXi

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