

We are lucky to live in a universe made for us

September 15 2015, by Geraint Lewis



Like a cosmic roulette wheel, we exist because of a very lucky combination of factors. Credit: NASA/JPL-Caltech

To a human, the universe might seem like a very inhospitable place. In the vacuum of space, you would rapidly suffocate, while on the surface of a star you would be burnt to a crisp. As far as we know, all life is confined to a sliver of an atmosphere surrounding the rocky planet we inhabit.

But while the origin of life on Earth remains mysterious, there are bigger questions to answer. Namely: why do the laws of physics permit any life

at all?

Hang on, *the laws of physics*? Surely they are a universal given and life just gets on with it?

But remember that the [universe](#) is built of fundamental pieces, particles and forces, which are the building blocks of everything we see around us. And we simply don't know why these pieces have the properties they do.

There are many observational facts about our universe, such as electrons weighing almost nothing, while some of their quark cousins are thousands of times more massive. And gravity being incredibly weak compared to the immense forces that hold atomic nuclei together.

Why is our universe built this way? We just don't know.

But what if...?

This means we can ask "what if" questions. What if the electron was massive and quarks were fleeting? What if electromagnetism was stronger than the nuclear strong force? If so, what would that universe be like?

Let's consider [carbon](#), an element forged in the hearts of massive stars, and an element essential to life as we know it.

Initial calculations of such stellar furnaces showed that they were apparently inefficient in making [carbon](#). Then the British astronomer [Fred Hoyle realised](#) the carbon nucleus possesses a special property, a resonance, that enhanced the efficiency.

But if the strength of the [strong nuclear force](#) was only fractionally

different, it would wipe out this property and leave the universe relatively devoid of carbon – and, thus, life.

The story doesn't end there. Once carbon is made, it is ripe to be transmuted into heavier elements, particularly [oxygen](#). It turns out that oxygen, due to the strength of the strong nuclear force, lacks the particular resonance properties that enhanced the efficiency of carbon creation.

This prevents all of the carbon being quickly consumed. The specific strength of the [strong force](#) has thus resulted in a universe with an almost equal mix of carbon and oxygen, a bonus for life on Earth.

Death of a universe

This is but a single example. We can play "what if" games with the properties of all of the fundamental bits of the universe. With each change we can ask, "What would the universe be like?"

The answers are quite stark. Straying just a little from the convivial conditions that we experience in our universe typically leads to a sterile cosmos.

This might be a bland universe, without the complexity required to store and process the information central to life. Or a universe that expands too quickly for matter to condense into stars, galaxies and planets. Or one that completely re-collapses again in a matter of moments after being born. Any complex [life](#) would be impossible!

The questions do not end there. In our universe, we live with the comfort of a certain mix of space and time, and a seemingly understandable mathematical framework that underpins science as we know it. Why is the universe so predictable and understandable? Would we be able to ask

such a question if it wasn't?

Our universe appears to balance on a knife-edge of stability. But why?

One of a multiverse

To some, science will simply fix it all. Perhaps, if we discover the "Theory of Everything", uniting quantum mechanics with Einstein's relativity, all of the relative masses and strengths of the fundamental pieces will be absolutely defined, with no mysteries remaining. To others, this is little more than wishful thinking.

Some seek solace in a creator, an omnipotent being that finely-tuned the properties of the universe to allow us to be here. But the move from the scientific into the supernatural leaves many uncomfortable.

There is, however, another possible solution, one guided by the murky and confused musings at the edge of science. Super-strings or M-theory (or whatever these will evolve into) suggest that the fundamental properties of the universe are not unique, but are somehow chosen by some cosmic roll of the dice when it was born.

This gives us a possible explanation of the seemingly special properties of the universe in which we live.

We are not the only universe, but just one in a semi-infinite sea of universes, each with their own peculiar set of physical properties, laws and particles, lifetimes and ultimately mathematical frameworks. As we have seen, the vast majority of these other universes in the overall multiverse are dead and sterile.

The only way we can exist to ask the question "why are we here?" is that we happen to find ourselves in a universe conducive to our very

existence. In any other universe, we simply wouldn't be around to wonder why we didn't exist.

If the multiverse picture is correct, we have to accept that the [fundamental properties](#) of the universe were ultimately dished out in a game of cosmic roulette, a spin of the wheel that we appear to have won.

Thus we truly live in a fortunate universe.

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