THOUGHTS ON GENEROSITY

DOES THE COSMOS CARE?

BY
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We shouldn't be here. We shouldn't exist. We're a cosmic fluke, a galactic accident. A mistake, even.

We humans are ridiculously fragile. Heat us up or cool us down by just a fraction, and we expire. Change the composition of the air we breathe by just a few per cent, and we perish. Withhold any number of complex molecules or key trace elements from our diet, and we sicken and die. So why are we here? How is it possible that life on Earth has not only survived for billions of years, but has even flourished and expanded with the passage of time?

At first glance the universe seems a harsh place. Much of it is an empty, inhospitable vacuum at a frigid temperature of -270 C. Occasionally, a cosmic traveller might encounter the welcoming beacon of a star. But stars are not steady sources of warmth or gently twinkling points of light, they are gargantuan, boiling balls of gas at temperatures of thousands of degrees, which emit endless torrents of harmful radiation. Often, when these stars reach the end of their lives, they detonate in catastrophic supernova explosions, laying waste to vast expanses around them. Others collapse into black holes, and spend the rest of eternity sucking in anything that strays too close.

But look a little closer and you will discover a universe that is remarkable in its generosity. A surprisingly nurturing, solicitous universe that has seemingly bent over backwards over the eons in order to create at least one tiny corner of the cosmos in which life, then intelligence, then sentience, could all emerge.

There is overwhelming evidence that space and time both came into abrupt existence 13.75 billion years ago, in the sudden moment of cosmic creation we call the Big Bang. Within twenty minutes of the Big Bang, as the cosmos rapidly expanded and cooled, the basic atomic proportions of the universe took shape: 75 per cent of the matter that was forged in the intense furnaces of the early universe was hydrogen, and 25 per cent was helium. Apart from some traces of lithium, that was pretty much it. But while clouds of hydrogen and helium might not be able to shed tears or sing opera, they have mass, and therefore exert gravity. With the passage of time, these primordial clouds slowly collapsed under gravity's gentle influence. After hundreds of millions of years, the dense, hot cores of these clouds ignited: the universe began to fill with light as the first stars turned on.

The heat and light of a star come from nuclear fusion, the same terrible, furious, atomic reaction that powers a hydrogen bomb. In those very first stars, hydrogen was fused to form helium, and helium was fused to form carbon. These first stars lived brief, intense lives, quickly consuming their fuel and then catastrophically exploding, scattering their own ashes back into space. When the next generation of stars came to life, fusion could run its course again, this time turning carbon into additional elements: oxygen, neon, sodium and magnesium. After they had exploded, a third generation of stars used the recycled star-stuff as their own fuel, forging silicon, sulphur and phosphorus. With each successive round of star birth, the chemists' treasured periodic table gradually came into being.

Fast-forward nine billion years or so, and clouds of gas throughout the universe had become rich with almost every element known. At some point, like trillions of times before, a cloud of gas collapsed under gravity, began shining, and became a yellow star like any other. But this time not all of the gas cloud collapsed. A tiny, insignificant fragment remained, which eventually coalesced into clumps of varying sizes, and began to orbit around the central fiery globe. The largest clumps became the mighty gas giants of our solar system: Jupiter, Saturn, Uranus and Neptune. Four smaller masses became the rocky inner planets: Mercury, Venus, Mars, and our home, the planet Earth.

At this point there was nothing on Earth even remotely resembling life. But thanks to the stellar furnaces that had worked unceasingly for billions of years, our planet was replete with oxygen, carbon, nitrogen, and all the other materials needed for living creatures to someday emerge. The Big Bang, then gravity, then starlight, was all it took to furnish the panoply of elements needed to make a human being—indeed, we are stardust. Every atom of every person who has ever lived was there right from the moment our planet formed, ready and waiting to be assembled in just the right way. There's the oxygen and carbon that make up more than 80 per cent of our bodies. There's the nitrogen and phosphorus threaded throughout our DNA. And there's the calcium in our bones, the iron in our blood, and even the zinc in our eyeballs. From the perspective of biology, all this is a given. But from the perspective of cosmology, the palette of chemical elements that comprises a human being is the fingerprint of the glittering night sky.

However, providing the raw ingredients was not enough. Liquid water is absolutely essential—no life form on Earth can survive without it. For a planet to host water it must be exquisitely positioned—only between a tiny sliver of temperatures does the amazing H^2O molecule exist as liquid water. Put the planet in a tight orbit around its parent, and the oceans will immediately boil away. Move it too far out, and the seas will freeze solid. But get the orbit just right, and you will have a beautiful blue orb, full of rivers, lakes and rainstorms. What we take for granted, whenever we fill a bathtub or sit by the seaside, is something universally special.

This hairline equilibrium sounds a little like Goldilocks sampling porridge, and astronomers routinely refer to our orbit around the sun as the 'Goldilocks Zone': the unique part of the solar system that's not too hot nor too cold, but just right for life like us to exist.

But even with all the atoms and molecules needed for living things to flourish, and the Earth's perfect distance from the sun to ensure that water is found everywhere, it is still not enough. The sun is continually bombarding every square inch of the solar system with harmful particles and deadly radiation. The one haven from this relentless assault is the planet Earth, whose thick atmosphere and strong magnetic field continually deflect or absorb these cosmic nasties, making our planet one of the few places in the universe where it's safe to walk unexposed.

It's hard to know why the universe has gone to all this trouble to form us out of stardust, to put us in just the right place and keep us safe from all the violence around us. Perhaps the cosmos has a purpose, to create order out of chaos, and we are the personification of how simple laws of physics can ultimately produce extraordinary beauty and complexity. Or perhaps we are not special or protected, but are the beneficiaries of an extraordinary cosmic coincidence. In an infinite universe, all imaginable permutations and possible: we could be the astronomical equivalent of the lucky ticket holder who wins the lottery. The winner asks, 'What are the chances?!' but does not take into account the thousands of others who bought a ticket but whose numbers didn't come up.

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Why are we here? Are we alone? Today, this quandary, once the realm of philosophers, is the subject of worldwide astronomical research, advancing at a breakneck pace. In less than a decade we may well know whether we're the cosmos' first and only living progeny, or if there are others.

Since the 1990s, we have known what we had long suspected: our solar system is not unique. There are other worlds—more than 700 at last count—shuttling around other, distant, stars. Most of these planets are beyond the most exotic imaginings of science fiction: planets the size of Jupiter but orbiting their parent stars in a matter of hours, and rocky planets like Earth, but bloated to ten times our size. We've so far found a few dozen planets in the Goldilocks Zone, but none as yet quite looks like home.

However, it is just a matter of time. As the torrent of discovery gathers pace, the day when we find a planet somewhere out there that looks just like ours will come. And once we find that first one, others will emerge. The excitement will build. Do they have oceans of water? Do they have atmospheres of oxygen? Ever-more powerful telescopes will provide crude maps of cloud cover and coastlines for these distant globes.

Finally, we'll try to answer the biggest question of all: does anybody like us live there? Messages of friendship will be transmitted. We'll wait decades or even centuries for a reply. But that doesn't matter—it will be worth the wait. Because when a response is received, it will change everything. The response will tell us that lightning has struck twice. It will tell us that the ridiculous series of coincidences that produced our sun, our planet, our first primordial ancestors, and eventually the human race, were perhaps not coincidences after all, but are the natural conclusion to a vast array of intricate cosmic processes. We'll come to realise that the entire Milky Way galaxy is teeming with intelligence, that the universe has conspired to create life wherever it can, in countless ways.

Sadly, I'm getting carried away. Perhaps this is indeed how things will unfold in the years to come. But right now, it's just us, here on Earth, wondering why such a seemingly empty, hostile, cosmos had a change of heart in our case, and gave us everything we needed to come about.

So next time you look up the sky on a clear, dark night, don't just pick out patterns of constellations or hope for a shooting star. Instead, marvel at the extraordinary fine-tuning and care that has allowed a universe full of stars and gas to produce a tiny planet full of beautiful blues, greens and greys.

Wonder at the patience of a cosmos that waited billions of years to form our sun, then carefully moulded the planets of the solar system, then let the Earth gradually evolve and age to produce the right cocktail of water, oxygen and sunlight. And be thrilled that through this stargazing we've been able to reveal the vast number of steps in a grand story, a story that has led to the arrival of us curious, wondrous, creative creatures who have never ceased exploring the world around them.

NASA/ESA, The Hubble Key Project Team and The High-Z Supernova Search Team

A star explodes as a supernova at lower left, temporarily outshining its entire galaxy. The violent death of a star hurls newly forged elements into the reaches of interstellar space, ensuring that the next generation of stars and planets forms from a rich cocktail of atoms and molecules.

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