Cosmic Conundrum

The universe seems uncannily well suited to the existence of life. Could that really be an accident?
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Dealing with cranks is an occupational hazard for most scientists, but it's especially bad for physicists and astronomers. Those who study the cosmos for a living tend to be bombarded with letters, calls and emails from would-be geniuses who insist they have refuted Einstein or devised a new theory of gravity or disproved the Big Bang. The telltale signs of crankdom are so consistent--a grandiose theory, minimal credentials, a messianic zeal--that scientists can usually spot them a mile off.

That's why the case of James Gardner is so surprising. He seems to fit the profile perfectly: he's a Portland, Ore., attorney, not a scientist, who argues--are you ready for this?--that our universe might have been manufactured by a race of superintelligent extraterrestrial beings. That is exactly the sort of idea that would normally have experts rolling their eyes, blocking e-mails and hoping the author won't corner them at a lecture or a conference.

But when Gardner's book Biocosmcame out last year, it carried jacket endorsements from a surprisingly eminent group of scientists. "A novel perspective on humankind's role in the universe," wrote Martin Rees, the astronomer royal of Britain and a Cambridge colleague of Stephen Hawking's. "There is little doubt that his ideas will change yours," wrote Seth Shostak, senior astronomer at the Search for Extraterrestrial Intelligence (SETI) Institute in California. "A magnificent one-stop account of the history of life," wrote complexity theorist John Casti, a co-founder of the Santa Fe Institute. Since then, Gardner has been welcomed at major planetariums and legitimate scientific conferences, explaining his ideas to a surprisingly interested public.

It's not that anyone actually buys Gardner's theory. He admits it's "farfetched," and even those scientists who find it stimulating think it's wildly improbable. But it does have one thing in its favor. The biocosm theory is an attempt, albeit a highly speculative one, to solve what just might be science's most profound mystery: why the universe, against all odds, is so remarkably hospitable to life.

Given that we haven't found any life beyond Earth yet, "remarkably hospitable" may sound a bit strong. At a deep level, though, it's true. Many of the most fundamental characteristics of our cosmos--the relative strengths of gravity, electromagnetism and the forces that operate inside atomic nuclei as well as the masses and relative abundances of different particles--are so finely tuned that if just one of them were even slightly different, life as we know it couldn't exist.

If the so-called weak nuclear interaction were a tiny bit stronger or weaker than it is, for example, stars wouldn't blow up in the mammoth supernovas that spread elements like carbon and oxygen out into space--and without those elements, there would be no water and no organic molecules. If the strong nuclear force were just one-half of 1% stronger or weaker, stars could not make carbon or oxygen in the first place. In 1999 Martin Rees postulated that there were "just six numbers" that

make life possible, although other theorists have since added several. And because there is no known law that requires those forces to have the values they do, scientists figure that there must be another explanation for how we got so lucky.

The proposition that the cosmos is--against all odds--perfectly tuned for life is known as the anthropic principle. And while it has been getting a lot of attention lately, there is no consensus on how seriously to take it. Some scientists are confident that there is a law that dictates the values of those key cosmic numbers, and when we find it, the anthropic problem will go away. Others think the answer is even simpler: if the numbers were any different than they are, we wouldn't be around to argue about them--case closed. "The anthropic principle," complains Fermilab astrophysicist Rocky Kolb, "is the duct tape of cosmology. It's not beautiful or elegant, and it sure as hell is not going to be permanent."

A vocal sector of the religious community, on the other hand, has seized on the anthropic principle as further evidence that God created the universe just for us--adding intellectual support to the so-called intelligent-design movement, which believes that the staggering complexity of nature can be explained only by assuming that some higher intelligence had a hand in designing it. Over the past several years, pitched battles have been fought in school boards in Ohio, Kansas, Georgia and Montana and, just weeks ago, in Dover County, Pa., over whether to give intelligent design and Darwin's theory of evolution equal time in classrooms.

Although intelligent design may appear to have found tiny pockets of support in the scientific community, most scientists consider appeals to a supernatural designer to be an intellectual dead end. Over and over in our history, natural phenomena--lightning, the changing of the seasons, the nature of the sun and moon--have been explained simply by saying God (or Zeus or Odin) did it, only to have that explanation fall away as science provided a more satisfying answer. Maybe we really have reached the limits of intellectual understanding, but few scientists are willing to give up quite yet, even on seemingly intractable problems.

In fact, lots of astrophysicists think the anthropic issue, rather than signaling a problem with modern science, points toward a deeper understanding of the universe. Rees likes to use our solar system as an analogy. Says Rees: "If Earth were the only planet in the universe, you'd be astonished that we just happened to be exactly the right distance from the sun to be habitable." That would be absurdly improbable, but it becomes much less so when you realize that the Milky Way almost certainly has millions of planets. With so many possibilities, it's not surprising that at least one planet is friendly to life.

And so, he contends, it might be with the cosmos. What we think of as the "universe," argues Rees, could well be just one of trillions of universes on an indescribably vaster stage called the multiverse. Each of those universes would have different laws and characteristics. Most of them are totally unlivable; like Earth, ours just happens to be one of the lucky ones.

On its face, the idea that multiple universes exist simultaneously in some parallel spheres of being sounds as farfetched as Gardner's biocosm theory. But scientists have been warily edging toward that conclusion from other directions for reasons that originally had nothing to do with the anthropic principle.

Take black holes. In the 1960s, Princeton physicist John Wheeler coined the term to describe a region where matter is so dense and gravity so intense that even light can't escape. At the core of a black hole is a singularity, a spot where density and gravity appear to become infinitely great--unleashing forces that could rip a hole in the very fabric of space-time and send a brand-new universe expanding in a direction undetectable and imperceptible to us. Since giant black holes lurk at the cores of many billions of galaxies and smaller holes are left behind by many billions of individual exploding stars, that could mean our cosmos has given birth to a staggering number of baby universes. And each of those could give birth in turn to billions more.

Then there is inflation theory, which came along in the 1980s as a kind of amendment to the original Big Bang. Its basic premise is that when the universe was less than a billionth of a billionth of a billionth of a second old, it briefly went through a period of supercharged expansion, ballooning from the size of a proton to the size of a grapefruit (and thus expanding at many, many times the speed of light). Then the expansion slowed to a much more stately pace. Improbable as the theory sounds, it has held up in every observation astronomers have managed to make.

And inflation, it turns out, leads once again to multiple universes. The inflationary period in our own region of space ran out of steam early on, but theorists, including Stanford University's Andrei Linde and Tufts University's Alexander Vilenkin, have shown that it should continue in others. Our own part of the cosmos took a sort of off ramp to evolve into the universe we see today, but the rest kept going, at breakneck speed--and that part is still going, spawning universes along the way, beyond our comprehension. In some, says Linde, the laws of physics could easily be so different that our sort of life would be impossible.

Multiple universes emerge from so-called superstring theory as well. This still evolving theory is based on the notion that, matter is made, not of particles, but of tiny, vibrating loops of energy called strings. The strings exist in a world of up to 10 spatial dimensions, all but three of which are too minute for us to perceive. Strange though it sounds, most physicists agree that it is the most likely candidate for the long-sought theory of everything that could finally unite relativity and quantum mechanics, the two great but mutually incompatible ideas of 20th century physics.

Superstring theory, which has lately been renamed Mtheory for reasons that interest only theoretical physicists, is so dauntingly complex that the smartest scientists in the world are still trying to nail it down. But among other things, it provides for multiple universes.

Last year a Stanford theorist named Shamit Kachru set out with some colleagues to calculate just how many different universes one particular version of string theory could produce. The number he came up with was a 1 followed by something like 100 zeros--roughly a hundred billion billion times the number of atoms in our universe. It was an answer that didn't please anyone. Says Max Tegmark, a theorist at the University of Pennsylvania: "People have tried very hard to get rid of these multiple universes and failed. They just don't like the concept; they think it's weird. And they're right. But don't we already have good evidence by now that the cosmos really is weird?" To Einstein's celebrated musing about whether God had a choice in creating the universe, the answer seems to be a resounding yes: all sorts of universes are possible.

Not everyone is convinced that the anthropic principle is sound evidence for a multiverse, though. "In my view," says cosmologist George Ellis, of the University of Cape Town in South Africa:

"Belief in multiple universes is just as much a matter of faith as any other religious belief." Even scientists who are willing to entertain the anthropic position are wary, with good reason. "Astronomers have been burned over and over again," says SETI's Shostak, "on beliefs that seemed to imply we're special--that we're at the center of the solar system or the center of the galaxy, or that the Milky Way is the only galaxy in the universe. Every time, it turned out that we weren't special after all. We just didn't have enough knowledge."

Besides, it's easy to see the anthropic principle as an explanation of last resort. When he first began looking at it back in the late 1980s, particle theorist Steven Weinberg of the University of Texas hoped the anthropic principle might go away. But the opposite happened. "It's not something that we're particularly happy about," he says. Every physicist dreams of being able to calculate everything from a set of fundamental laws. But at the same time, Weinberg says, "it's important to be realistic. We may just have to get used to the fact that some of the things we call fundamental constants may be historical accidents."

For example, he observes, when it was first realized that planets go around the sun, astronomers hoped they might find an underlying principle that would explain why the planets orbit at the precise distances they do. But now we know the orbits are the result of pure chance. The elliptical shapes of planetary orbits, on the other hand, led to the truly profound discovery of Newton's laws of gravity. "My own feeling," says Brian Greene, a superstring theorist at Columbia University and author of the best-selling The Fabric of the Cosmos, "is that we can give a deeper explanation of why this universe, with its particular properties, came to be."

That may be the most important result of anthropic thinking: it pushes scientists to ask all sorts of new questions--questions that may ultimately provoke a new scientific revolution. For example, how improbable is our universe? If the answer is not very, there ought to be lots of universes like our own. Or if multiple universes come about through inflation, as M.I.T. cosmologist Alan Guth suspects, "does it produce all types of universes about equally, or does it produce just a few types? We don't know the answer--yet."

We also don't know how different from our own a universe could be and still support life. Change one thing--the strength of gravity, say--and life might be impossible. Change several at once, though, as Anthony Aguirre, of the University of California at Santa Cruz, has tried in his calculations, and you get a surprise. It is possible, he says, to get life-friendly universes by twiddling with multiple knobs.

The anthropic principle still makes many scientists uncomfortable--and not just because it gives comfort to theologians. That discomfort, says Stanford theorist Leonard Susskind, is all to the good. "In the end," he observes, "it doesn't matter whether the anthropic principle makes us happy. What matters is whether it's true"--that is, whether cosmic numbers really are as arbitrary as they seem. If they aren't, physics may eventually succeed in explaining many features of our world that seem so puzzling today. And if the anthropic principle is true? Well, then, says Aguirre, "the universe will seem even more preposterous and baroque than before."