The Universe as Happy Conspiracy

There Are Too Many Coincidences for Life to Have Happened by Chance

By Eugene F. Mallove

PHYSICISTS WHO STUDY cosmology are knocking loudly on heaven's door, seeking, as Einstein said, to "know what was in God's mind" when the universe started 10 to 20 billion years ago. Some scientists are awestruck by the numerous improbable physical coincidences in the universe, without which life could not exist. Their work is forcing them to ask the ultimate philosphical question, long the province of religion: Did the universe come into being by chance or by design?

Going against centuries of scientific tradition that has been neutral or indifferent to such questions, some cosmologists are proposing that the universe has been perfectly "designed" for life in a way that could not have happened "by chance." British cosmologist Paul Davies, in his ironically titled book, "The Accidental Universe," wrote, "Recent discoveries about the primeval cosmos oblige us to accept that the expanding universe has been set up in its motion with a cooperation of astonishing precision."

John Wheeler, a physicist with towering credentials, gets almost theological when he suggests that the principles of quantum mechanics *require* the cosmos to create a phenomenon like life that observes and contemplates. This interpretation goes so far as to hold that, without something like us to observe it, the universe — as understood in terms of physics — would be impossible.

Cosmologists are far from claiming a "proof of God." Yet in the open scientific literature, they are exploring the very meaning of "chance creation." What a surprise to see the usual domain of religion invaded by mainstream science, no doubt causing discomfiture among some scientists and religionists.

Scientists believe that life, as we know it on Earth, originated and evolved on a planetary surface only by the grace of many congenial circumstances — not too warm, not too cold, the right chemicals, the right energies, neither too little nor too much stability in the environment.

But these fortunate details of biological evolution on one small planet are not what intrigues cosmologists. They question instead why the universe is set up so that atoms hold together exactly the way they do — not tighter, not looser. They want to know why the laws of nature are set up so that stars burn as slowly as they do. They want to know why the universe's bubble of space and time was set up so that it expands neither more nor less slowly than it does.

The reason they are so astonished by the "coincidences" they find in nature is that our universe is set up to do three very unusual things: foster the complexity epitomized by life, permit highly complex objects to stay intact over long periods of time and yet allow for gradual change that can lead to even greater complexity.

No matter how wildly you speculate on what kinds of life could exist under different physical circumstances, it is hard to believe that self-aware organisms could develop except in a universe that allows for the above three qualities.

For example, our universe allows something as intricate as our genetic code to come together chemically from very basic materials. It also allows that code to survive unchanged for eons; (if the universe were hostile to complexity, the molecules might break down in short order, or never form at all and, of course, we would no longer exist). Yet it does allow for change, and therefore evolution; (in some alternate universe, a crystal, for example, might develop that was very complex and very long-lived, but if it could not evolve, there is no apparent way that it could ever become self-aware).

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UNIVERSE, From B1

Why is the universe set up in such a precise, delicate, highly improbable way, these physicists ask. There is an infinity of ways that the universe could have been set up that would have been more "simple," with fewer improbable coincidences.

Of course, in almost any of these "simpler" universes, the odds for the development of anything as complicated as life — no matter how you imagine it — would be nil.

In short, the cosmologists are asking why the laws of physics are as they are — with the precise forms and exact numerical constants that repeatedly show up in their calculations. It is extraordinary that science has come so far that it can question the "why" and not just the "what and how" of physics.

The first person to hint of something strangely coincidental about the cosmos was physics Nobel laureate Paul Dirac. In 1937 he noticed that numbers with the order of magnitude of one followed by 40 zeroes kept appearing unexpectedly.

The ratio of the huge electromagnetic force between two particles (protons or electrons) to the much weaker gravitational force between them was of that approximate size. He also noticed that the ratio of the age of the universe to the time for light to zip across a proton's length (the smallest distance he knew about) was also about one followed by 40 zeroes. The number of protons that would equal the mass of the visible universe was, remarkably, simply that magic number multiplied by itself. These were all "pure numbers" with no units like feet, meters or hours — anyone in the universe would derive the same numbers.

Dirac believed that this showed a "deep connection between cosmology and atomic theory" — between the macrocosm and the microcosm.

British astrophysicist Brandon Carter reignited interest in this form of scientific "numerology" in the early 1970s. He began to codify a variety of cosmic conditions necessary for life under the general rubric of what he called "the anthropic principle." There are actually at least two versions of this principle, which have acquired respectively the names the "weak" and the "strong" anthropic principle.

The weak anthropic principle merely says that since we are alive and contemplating the universe, any cosmological observations had better take that into account and realize that we of necessity live under special conditions. In Carter's almost platitudinous words, "What we can expect to observe must be restricted by the conditions necessary for our presence as observers."

The strong anthropic principle, on the other hand, says that any meaningful or real universe must evolve life.

Under the weak principle, the universe is simply passing though a phase in which conditions are right and we exist. But under the strong principle, the basic physical laws are seen as requiring life — observers — to evolve ultimately!

Are we dreaming? Has the Copernican revolution — that destroyed the idea that the earth is the center of the universe — run full circle to embrace the notion that the universe revolves around life? Though many resist the anthropic view, some cosmologists seem, indeed, to have turned fully around, even though they don't say they have found the handiwork of a Grand Designer among the stars.

Physicists B. J. Carr and M. J. Rees reviewed the state of knowledge about anthropic coincidences in a 1979 article in the magazine Nature. After detailed mathematical examination they concluded that, "Several aspects of our universe — some of which seem to be prerequisites for the evolution of any form of life — depend rather delicately on apparent coincidences among the physical constants."

What are some of the coincidences that prompt this chorus of physicists venerating the cosmos? One of the most amazing facts about the universe is that it is bathed in the cold afterglow of its extremely hot creation billions of years ago. With radiotelescopes astronomers can pick up this so-called "3 degree Kelvin" radiation as a hiss that is uniform in intensity in all directions, varying by no more than one part in 10,000.

This uniformity in all directions — called isotropy — had to be set up by astoundingly uniform initial conditions in the Big Bang. If the radiation were not highly isotropic, for various reasons the temperature of space would now be intolerably high and the universe could not support chemically organized life.

Paul Davies wrote, "The present temperature of space requires that the expansion rate at [the birth of the universe] be fine-tuned in different directions to within one part in one followed by 40 zeroes. This is another stunning example of 'cosmic conspiracy.' "

Gravity is incredibly weaker than the electromagnetic force that makes the dense nucleus of an atom hug a cloud of fleeting electrons. If gravity had been slightly stronger — still allowing it to be much weaker than electromagnetism — stars would have burned much faster and hotter and the sun would long since have used up its hydrogen. Life would probably never have had a chance to evolve.

Had gravity been slightly weaker, then all stars would have been dim "red dwarfs," Paul Davies added. "The extremely long time scale required for major cosmic change is directly attributable to the weakness of gravity."

The most ubiquitous nuclear particle in the universe is the neutrino — 1 billion of them for every proton and electron — another relic of the Big Bang. They hardly interact with matter and have been thought to have no mass, just like "particles" of light — photons. But recent experiments have revealed that some neutrinos have a very tiny mass.

Up to a certain point there would be no problem, but even a tiny neutrino mass might cause the universe to collapse on itself due to the increased gravity. It doesn't because either the neutrino is really massless or is providently not massive enough to "close" the universe. Some theoreticians have proved that too massive neutrinos would also have prevented the formation of galaxies. We should be thankful for small things.

Life as we know it requires the spectacular deaths of massive exploding stars called supernovas. Near the end of their lives, supernovas cook up many elements heavier than helium. When these stars explode, they scatter these atoms all over the universe to be recycled in the bodies of living organisms and in the bowels of planets. This explosion is thought to depend on an enormous pressure of neutrinos as the star tries to collapse on itself. As it happens, the weak nuclear force is neither too strong nor too weak to prevent this pressure, and the universe allows these crucial explosions to occur.

Another numerical accident: The weak nuclear force is related to the strength of gravity in such a way that mainly hydrogen rather than helium emerged as the dominant element in the earliest stage of the universe. If that relation had been slightly different in one direction, then mostly helium would have formed and there would have been more rapid burning and shorter-lived stars.

More important, there would have been almost no hydrogen to form water. Then where would life be? According to Paul Davies, "The nuclear content of the universe is thus highly sensitive to what appears to be a random nuclear accident involving quite distinct areas of physics."

The strong force binds protons and neutrons together in the atomic nucleus. If that force were only one-half its value, then such essential elements as carbon and iron would have been unstable and would not have survived long. An only 2-percent increase in the strength of the nuclear force would have burned up all the hydrogen catastrophically early in the universe.

The list of cosmic coincidences goes on and on. The skeptic might suggest correctly that there could be an unknown underlying physical principle (other than the anthropic) that would force the universe to be so hospitable to life in all these ways — a fact that Paul Davies would find no less remarkable. He wrote that, "Whether the laws of nature can force the coincidences on the universe or not, the fact that these relations are necessary for our existence is surely one of the most fascinating discoveries of modern science."

Physics already had some theories lying in wait that could explain the multitude of anthropic coincidences, but at the expense of adopting an intellectual burden equally disturbing — or delightful! One solution was proposed by John Wheeler, a world-renowned physicist in gravitational and quantum theory. He suggests that there is an "ensemble of universes," each with its own set of physical laws and constants. We just happen to be in one universe that is congenial to life.

These worlds might exist in parallel or sequentially, if it were the habit of universes to expand and then collapse. In some of them there could be structure and forms of "life" that we could never imagine. But in the words of physicists Carr and Rees, "Most are 'stillborn,' in that the prevailing physical laws do not allow anything interesting to happen in them; only those which start off with the right constants can ever become 'aware of themselves.' " This is a way of getting a good universe "by chance."

Then there is the "many worlds" interpretation of quantum mechanics. This theory, invented by Hugh Everett III in the 1950s, suggests that the universe continuously bifurcates at each measurement by an "observer" into a treelike infinity of parallel and disconnected worlds. All

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possible things happen "somewhere." In one universe, a cat dies, and in another it continues to live. So we have a set of infinitely expanding parallel universes in this theory, too — more opportunity to get these anthropic "coincidences" by sheer chance.

Paul Davies expresses a feeling that many people might have about multiple universes. "To explain the coincidences by invoking an infinity of useless universes seems like carrying excess baggage to the extreme. Yet it must be concluded that the alternatives — a universe deliberately created for habitation, or one in which the very special structure is regarded as a pure miracle are also open to philosophical challenge."

The Copernican revolution began in the 16th century and displaced the Earth as the center of the universe. The sun, not the Earth, was the center of the solar system. Then the sun was but one of many other stars, appearing pointlike and distant in space. The stars were organized into an island universe of hundreds of billions of stars called the Milky Way galaxy. And finally, the Milky Way was itself dethroned and became only one of hundreds of billions of galaxies scattered through space.

This process of deprovincialization has been very sobering and beneficial to the unchecked human ego, but it had the unfortunate side effect of seeming to demote the importance of life in the universe. Even if life existed on other worlds, what importance could it have compared to the vastness of time and space?

If it were just an "accident" that life arose on a particular planet and acquired a certain form, surely life could have no more importance than the equally "accidental" major features of the universe — galaxies, stars and planets.

But now some cosmologists are asking whether life may be of central importance to the cosmos. Physicist Wheeler, a firm believer in the central role of quantum mechanics, takes an extreme anthropic view. He feels the cosmos needs "observer participancy" in order for it to be sustained. In his view, "observers" — whether inanimate event recorders such as rocks that retain traces of cosmic rays, or conscious beings — in some sense are needed to "create" the universe. They establish a link of observation through an unimaginably vast network of elementary quantum phenomena stretching back to the beginning of the universe. In this way, human beings — all life forms — are observers of the creation of the universe and in a strange quantum-mechanical sense, bring it into being.

Wheeler is a brilliant and respected scientist, but it stretches credulity to believe that in any sense we helped create the universe. But then "ordinary" quantum mechanics, which all physicists believe today, already tortures common sense.

Philosopher Kenneth Wilkie, meanwhile, giving a philosopher's view of the anthropic principle in Sky and Telescope magazine last year, claims to find concealed anthropocentric assumptions in the anthropic principle. He challenges the principle's proponents: "If the ultimate outcome of the history of the universe is an earth populated by some primitive lifeforms, or one devoid of all life, would the defenders of the principle be prepared to say that it was for the sake of this end that the physical constants are as they are?"

We know so little about all the possible ways "life" could exist even in our own universe. Perhaps some of the strange nuclear or electromagnetic lifeforms imagined by physicists-turned-science-fiction writers should have their "anthropic" principles too. They might be able to exist under a broader range of conditions.

Some will take from all this speculation the impression that theorizing physicists have stumbled upon a Grand Designer — God — hidden within their theories and equations. Others, adopting an agnostic view, may simply conclude that whether by design, chance or process not yet conceived we inhabit a very good world — a very promising universe. It is written in the great book of the skies.