Natural Selection and the Emergence of Mind [excerpt]

Karl Popper

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I think that science suggests to us (tentatively of course) a picture of a universe that is inventive or even creative; of a universe in which *new things* emerge on *new levels*.

There is, on the first level, the theory of the emergence of heavy atomic nuclei in the center of big stars, and, on a higher level, the evidence for the emergence somewhere in space of organic molecules.

On the next level, there is the emergence of life. Even if the origin of life should one day become reproducible in the laboratory, life creates something that is utterly new in the universe: the peculiar activity of organisms; especially the often purposeful actions of animals; and animal problem solving. All organisms are constant problem solvers; even though they are not conscious of most of the problems they are trying to solve.

On the next level, the great step is the emergence of conscious states. With the distinction between conscious states and unconscious states, again something utterly new and of the greatest importance enters the universe. It is a new world: the world of conscious experience.
On the next level, this is followed by the emergence of the products of the human mind, such as the works of art; and also the works of science; especially scientific theories.

I think that scientists, however sceptical, are bound to admit that the universe, or nature, or whatever we may call it, is creative. For it has produced creative men: it has produced Shakespeare and Michelangelo and Mozart, and thus indirectly their works. It has produced Darwin, and so created the theory of natural selection. Natural selection has destroyed the proof for the miraculous specific intervention of the Creator. But it has left us with the marvel of the creativeness of the universe, of life, and of the human mind. Although science has nothing to say about a personal Creator, the fact of the emergence of novelty, and of creativity, can hardly be denied.

I conjecture that life, and later also mind, have evolved or emerged in a universe that was, up to a certain time, lifeless and mindless. Life, or living matter, somehow emerged from nonliving matter; and it does not seem completely impossible that we shall one day know how this happened . . .

I regard the emergence of mind as a tremendous event in the evolution of life. Mind illuminates the universe; and I regard the work of a great scientist like Darwin as important just because it contributes so much to this illumination. Herbert Feigl reports that Einstein said to him: "But for this internal illumination, the universe would be just a rubbish heap."

The Higgs Field & The Big Bang

Null Session [pseudonym]

http://www.nullsession.net/2009/the-higgs-field-the-big-bang/

Let me explain what the Higgs field is. Fields are all around us. All the time we are submerged in a sea of electromagnetic fields. From radio signals, cell phones, satellite communications, radar… there's just about no escaping them! Electromagnetic fields are made up of photons, because they are the EM force carriers. The carriers of the weak force, the W and Z bosons, were discovered (as predicted) in the 1980s, as I mentioned above. The carrier particles of the strong force, that holds the nucleus of an atom together, is the gluon. And, even though we have yet to discover it, probably due to gravity being so much weaker than the other three forces, the graviton is believed to be the mediator of the gravitational force. And, we are quite familiar with living in a gravitational field!

Physicists suggest that there was another field, the Higgs field, mediated by the Higgs boson. During the first second, the temperatures started out so high (during the Planck era) that the Higgs field was wildly fluctuating. As things cooled below a trillion degrees, the Higgs field settled, but it settled to a nonzero value . . . This means the Higgs force is all around us. In fact, all of space is permeated with a “Higgs Ocean”. Scientists hope to prove this is the case by uncovering the Higgs particle with next-generation accelerators, like the LHC.

The Higgs field is where objects get their mass, or how we feel inertia. If the Higgs field is there, it explains why the zoo of subatomic particles have the masses they do. Particles that feel more resistance in the Higgs field, are measured to have a larger mass. The photon moves with no resistance, thus has zero mass. In fact, we can see this is why the speed of a photon in the vacuum is the fastest any object can go. Particles with mass MUST feel a greater resistance, and thus a slowing effect as they move through the Higgs Ocean. So, when the Big Bang happened, at first the concept of mass was meaningless. As the universe expanded and cooled, it underwent phase changes, or symmetry breaking, where the different forces “froze out” and their exchange particles “gained mass” (or, at least experienced the effects of it).

Brian Greene [in *The Fabric of the Universe]* answers the question that may be on your mind now, “Isn’t the Higgs Ocean just another way of saying the cosmos is permeated with aether?” He says that yes, “it smacks of aether”. However, the fundamental difference is that aether was introduced as an analogy to how sound waves move through air. At the time, it was needed to explain how light moved through space, but we now know that light does not need a medium to propagate.

Greene goes on to discuss inflationary cosmology, and how it relates to where all the mass/energy making up the cosmos came from. He starts by explaining the work of Guth and Tye in the late 1970s. They believed that the Higgs field was basically fluctuating and ended on a “plateau” temporarily, providing a positive energy and a repulsive force that drove space to expand. Imagine that this field is like a spring. If you stretch it out, it wants to shrink, but if you compress it and confine it to a small volume, it wants to expand. (This is not related the how the Higgs field gives mass to particles, so we refer to it as the “Inflaton field”.) This period of inflation may have lasted only 10^{-35} seconds, but it drove the universe’s volume to increase by 90 orders of magnitude or more! Thus, the Big Bang theory states that at 10^{-38}seconds, the universe underwent a violent inflationary period, “the equivalent of blowing a single strand of DNA up to the size of the Milky Way Galaxy in a billionth of a billionth of a billionth of a blink of an eye!”

Which brings me to another amazing distinction. We often try to explain to people how The Universe had to be smaller than an atom, yet contain all the mass and energy we see today in all the galaxies and stars and planets (and we know this makes up less than 5% of the universe, when you consider dark matter and dark energy). Greene explains that when the universe was tiny, about 10^{-26} cm across, before it underwent the rapid inflationary period, it could have been filled with the inflaton field — and weigh a mere twenty pounds! That would have infused enough energy, through the rapid expansion, to account for the vast universe we see today!

Jamming 20 pounds into a volume that tiny is still way, way beyond our present technological capabilities, so the likelihood anyone will be cooking up new universes in the lab are might slim, but it makes the creation of the universe a lot more fathomable. These are the kinds of issues we are trying to resolve with experiments like the LHC. This is what gets scientists excited! Combine that with the possibility that the Planck mission, or other missions to study the patterns of the microwave background in space (left over from the big bang), might tell us about what lies beyond the confines of our “observable universe”. This should blow your mind! Not only are we learning more about the universe, but we may learn things that we said a decade ago we “could” never know.

All of this IS fantastic, and it DOES get scientists excited, but we approach these tasks methodically and with humility. The fact that we can learn some things about the cosmos, does not delude us into thinking we are gods or that we can ever know it all. We accept that the universe is too vast and varied for us to ever fully experience, but we have bitten off a piece, and it tastes good!

We no longer need to make up tales to explain our origins. We probe beneath the atom and beyond the galaxies, and we understand that it is all tied together in ways that go beyond our human intuition. We have so many scientific results that fill so much of our natural model of the cosmos, that no dogmatic human can stop our progress and return us to the day when we could put everything in human terms, anthropomorphizing even the stars themselves. We are in the realm where we must rely on science. Not because science has surpassed superstition, and become a religion unto itself, but because it works. Science takes our observations and subjects them to a methodology that removes as much human bias as possible, and lets us understand nature without creating hobgoblins. If we someday found the universe was capricious and the scientific method failed, we would have to seek something better. We do not "believe" in science with a blind and enduring faith, instead we "trust" in science, because it works. We trust that gravity will work the same tomorrow.

We do not claim to know this irrefutably, and that is the point of science, as someone recently said to me, *"Trust, but verify"*. I think that sums up what science is. It is not a religion or a dogma, it is simply a way of thinking and approaching problems. It promises to take us on an amazing journey. After all, look how far we've come in 400 years since Galileo had the idea to turn a spyglass to the stars!

Does The Multiverse Really Exist? [excerpt]

Proof of parallel universes radically different from our own may still lie beyond the domain of science.

George Ellis

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In the past decade an extraordinary claim has captivated cosmologists: that the expanding universe we see around us is not the only one; that billions of other universes are out there, too. There is not one universe—there is a multiverse. In *Scientific American* articles and books such as Brian Greene's latest, *The Hidden Reality*, leading scientists have spoken of a super-Copernican revolution. In this view, not only is our planet one among many, but even our entire universe is insignificant on the cosmic scale of things. It is just one of countless universes, each doing its own thing.

The word "multiverse" has different meanings. Astronomers are able to see out to a distance of about 42 billion light-years, our cosmic visual horizon. We have no reason to suspect the universe stops there. Beyond it could be many—even infinitely many—domains much like the one we see. Each has a different initial distribution of matter, but the same laws of physics operate in all. Nearly all cosmologists today (including me) accept this type of multiverse, which Max Tegmark calls "level 1." Yet some go further. They suggest completely different kinds of universes, with different physics, different histories, maybe different numbers of spatial dimensions. Most will be sterile, although some will be teeming with life. A chief proponent of this "level 2" multiverse is Alexander Vilenkin, who paints a dramatic picture of an infinite set of universes with an infinite number of galaxies, an infinite number of planets and an infinite number of people with your name who are reading this article.

Similar claims have been made since antiquity by many cultures. What is new is the assertion that the multiverse is a scientific theory, with all that implies about being mathematically rigorous and experimentally testable. I am skeptical about this claim. I do not believe the existence of those other universes has been proved—or ever could be. Proponents of the multiverse, as well as greatly enlarging our conception of physical reality, are implicitly redefining what is meant by "science."

OVER THE HORIZON

Those who subscribe to a broad conception of the multiverse have various proposals as to how such a proliferation of universes might arise and where they would all reside. They might be sitting in regions of space far beyond our own, as envisaged by the chaotic inflation model of Alan H. Guth, Andrei Linde and others. They might exist at different epochs of time, as proposed in the cyclic universe model of Paul J. Steinhardt and Neil Turok. They might exist in the same space we do but in a different branch of the quantum wave function, as advocated by David Deutsch. They might not have a location, being completely disconnected from our spacetime, as suggested by Tegmark and Dennis Sciama.

Of these options, the most widely accepted is that of chaotic inflation, and I will concentrate on it; however, most of my remarks apply to all the other proposals as well. The idea is that space at large is an eternally expanding void, within which quantum effects continually spawn new universes like a child blowing bubbles. The concept of inflation goes back to the 1980s, and physicists have elaborated on it based on their most comprehensive theory of nature: string theory. String theory allows bubbles to look very different from one another. In effect, each begins life not only with a random distribution of matter but also with random types of matter. Our universe contains particles such as electrons and quarks interacting through forces such as electromagnetism; other universes may have very different types of particles and forces—which is to say, different local laws of physics. The full set of allowed local laws is known as the landscape. In some interpretations of string theory, the landscape is immense, ensuring a tremendous diversity of universes.

Many physicists who talk about the multiverse, especially advocates of the string landscape, do not care much about parallel universes per se. For them, objections to the multiverse as a concept are unimportant. Their theories live or die based on internal consistency and, one hopes, eventual laboratory testing. They assume a multiverse context for their theories without worrying about how it comes to be—which is what concerns cosmologists.

For a cosmologist, the basic problem with all multiverse proposals is the presence of a cosmic visual horizon. The horizon is the limit to how far away we can see, because signals traveling toward us at the speed of light (which is finite) have not had time since the beginning of the universe to reach us from farther out. All the parallel universes lie outside our horizon and remain beyond our capacity to see, ever, no matter how technology evolves. In fact, they are too far away to have had any influence on our universe whatsoever. That is why none of the claims made by multiverse enthusiasts can be directly substantiated.

The proponents are telling us we can state in broad terms what happens 1,000 times as far as our cosmic horizon, 10^{100} times, $10^{1,000,000}$ times, an infinity—all from data we obtain within the horizon. It is an extrapolation of an extraordinary kind. Maybe the universe closes up on a very large scale, and there is no infinity out there. Maybe all the matter in the universe ends somewhere, and there is empty space forever after. Maybe space and time come to an end at a singularity that bounds the universe. We just do not know what actually happens, for we have no information about these regions and never will . . .

The Case for Parallel Universes

Why the multiverse, crazy as it sounds, is a solid scientific idea

By Alexander Vilenkin

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The universe as we know it originated in a great explosion that we call the big bang. For nearly a century cosmologists have been studying the aftermath of this explosion: how the universe expanded and cooled down, and how galaxies were gradually pulled together by gravity. The nature of the bang itself has come into focus only relatively recently. It is the subject of the theory of inflation, which was developed in the early 1980s by Alan Guth, Andrei Linde and others, and has led to a radically new global view of the universe.

Inflation is a period of super-fast, accelerated expansion in early cosmic history. It is so fast that in a fraction of a second a tiny subatomic speck of space is blown to dimensions much greater than the entire currently observable region. At the end of inflation, the energy that drove the expansion ignites a hot fireball of particles and radiation. This is what we call the big bang. The end of inflation is triggered by quantum, probabilistic processes and does not occur everywhere at once. In our cosmic neighborhood, inflation ended 13.7 billion years ago, but it still continues in remote parts of the universe, and other “normal” regions like ours are constantly being formed. The new regions appear as tiny, microscopic bubbles and immediately start to grow. The bubbles keep growing without bound; in the meantime they are driven apart by the inflationary expansion, making room for more bubbles to form. This never-ending process is called eternal inflation. We live in one of the bubbles and can observe only a small part of it. No matter how fast we travel, we cannot catch up with the expanding boundaries of our bubble, so for all practical purposes we live in a self-contained bubble universe.

The theory of inflation explained some otherwise mysterious features of the big bang, which simply had to be postulated before. It also made a number of testable predictions, which were then spectacularly confirmed by observations. By now inflation has become the leading cosmological paradigm.

Another key aspect of the new worldview derives from string theory, which is at present our best candidate for the fundamental theory of nature. String theory admits an immense number of solutions describing bubble universes with diverse physical properties. The quantities we call constants of nature, such as the masses of elementary particles, Newton's gravitational constant, and so on, take different values in different bubble types. Now combine this with the theory of inflation. Each bubble type has a certain probability to form in the inflating space. So inevitably, an unlimited number of bubbles of all possible types will be formed in the course of eternal inflation.

This picture of the universe, or *multiverse*, as it is called, explains the long-standing mystery of why the constants of nature appear to be fine-tuned for the emergence of life. The reason is that intelligent observers exist only in those rare bubbles in which, by pure chance, the constants happen to be just right for life to evolve. The rest of the multiverse remains barren, but no one is there to complain about that.

Some of my physicist colleagues find the multiverse theory alarming. Any theory in physics stands or falls depending on whether its predictions agree with the data. But how can we verify the existence of other bubble universes? Paul Steinhardt and George Ellis have argued, for example, that the multiverse theory is unscientific, because it cannot be tested, even in principle. Surprisingly, observational tests of the multiverse picture may in fact be possible. Anthony Aguirre, Matt Johnson, Matt Kleban and others have pointed out that a collision of our expanding bubble with another bubble in the multiverse would produce an imprint in the cosmic background radiation— a round spot of higher or lower radiation intensity. A detection of such a spot with the predicted intensity profile would provide direct evidence for the existence of other bubble universes. The search is now on, but unfortunately there is no guarantee that a bubble collision has occurred within our cosmic horizon.

There is also another approach that one can follow. We can use our theoretical model of the multiverse to predict the constants of nature that we can expect to measure in our local region. If the constants vary from one bubble universe to another, their local values cannot be predicted with certainty, but we can still make *statistical* predictions. We can derive from the theory what values of the constants are most likely to be measured by a typical observer in the multiverse. Assuming that we are typical—the assumption that I called *the principle of mediocrity*— we can then predict the likely values of the constants in our bubble.

This strategy has been applied to the energy density of the vacuum, also known as "dark energy". Steven Weinberg has noted that in regions where dark energy is large, it causes the universe to expand very fast, preventing mater from clumping into galaxies and stars. Observers are not likely to evolve in such regions. Calculations showed that most galaxies (and therefore most observers) are in regions where the dark energy is about the same as the density of matter at the epoch of galaxy formation. The prediction is therefore that a similar value should be observed in our part of the universe.

For the most part, physicists did not take these ideas seriously, but much to their surprise, dark energy of roughly the expected magnitude was detected in astronomical observations in the late 1990s. This could be our first evidence that there is indeed a huge multiverse out there. It has changed many minds.

The multiverse theory is still in its infancy, and some conceptual problems remain to be resolved. But, as Leonard Susskind wrote, "I would bet that at the turn of the 22nd century philosophers and physicists will look nostalgically at the present and recall a golden age in which the narrow provincial 20th century concept of the universe gave way to a bigger better [multiverse] ... of mind-boggling proportions."