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Origin of life: a deterministic or a chance event

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Abstract

The idea of Anthropic Universe holds that the Universe was designed for creation of life. In the field of origin of life a similar view called determinism has been proposed by many biologists according to which, origin of life was predetermined. However, an alternative view is also there, called contingency, which advocates that life originated in this Universe just by chance. The present review summarizes the opinions of some workers in this field and also proposes that both determinism and contingency could have played their roles in origin of life.

The Deterministic view

We are very complex creatures living in a vast Universe. But we have not been allotted a very typical place in this Universe. We live on a planet orbiting an average sized simple star. The energy needed for life on earth comes from sun, but the complex structure of living beings emerges from the special conditions prevailing here on earth. Thus we can say that though we don't have a unique address of our home- the earth in the universe, our home itself is a unique place that has allowed us to be born, grow and evolve here in different directions. More so, we are living in a special time when the conditions are most optimum, at least on our planet. We exist here and now because of the exact relationship between the basic forces and the particles that construct this Universe (Gribbon and Rees, 1989). There is a school of scientists, who believe that our Universe is an anthropic Universe, i.e., it has some special properties that have made life inevitable. They believe that the Universe was designed the way that made the emergence of human beings most imminent. According to Christian de Duve *et al.*, (1991), 'the suitable initial conditions, the emergence of life is highly probable and governed by the laws of chemistry and physics.....'. In his further work, De Duve *et al.* (2002) went on to say that 'it is self evident that the Universe was pregnant with life and the biosphere with man'. There have been other great philosophers of science who have strongly favored the inevitability of life. Herbert Morowitz (1993) says, 'we have no reason to believe that biogenesis was not a series of chemical events subject to all of the laws governing atoms and their interactions' (Luisi, 2003). Similarly, Dyson (2006) says that the Universe is friendly to the evolution of life but we don't know why the Universe is so friendly. Our Universe is full of properties and coincidences which have been instrumental in creating life on this planet and a little variation in which could have made life impossible. John Gribbin and Martin Rees (1989) have summarized a number of such coincidences in their remarkable book, 'Cosmic Coincidences'. Some of the coincidences cited by them are being discussed in the following lines.

One important property of the Universe necessary for creation of life is the size and life span of stars. It has been estimated that intelligent life took about four billion years to evolve since the first living beings emerged on earth. On the other hand, the first living beings themselves took about a billion year to emerge on earth since its formation. Thus it is clear that intelligent life needs a long period to evolve. Since sun is the only source of all the energies required for evolution of life on earth, a long life of sun is a prerequisite for emergence of intelligent life. The life of sun or the stars in general, depends on their size. Stars are very big because they are gravitationally bound fusion reactors, and gravity is a weak force. Gravitational forces are 10^{36} times weaker than electrical forces. Since gravitational force of a body is two-thirds power of its mass, in any object with 10^{54} atoms or more (36 is two-thirds of 54), the gravitational forces created by these atoms will overpower the electrical forces that hold them together. So anything having more atoms than 10^{54} will start to get crushed by gravity and nuclear fusion will start. The nuclei of atoms will be squeezed together to make new nuclei and this provides the energy to ignite the object making it a star. Thus, if gravity were even weaker, stars would be bigger still. But if gravity were stronger, e.g. only 10^{26} times weaker than electrical forces, stars would be smaller (only about 10^{-15} times the size of the present sun) and would run through their life cycles more rapidly (in one year in the present case) without giving enough time to a planet for emergence of intelligent life on it.

Longer life span of stars was also necessary to manufacture the basic elements of life- carbon, nitrogen and phosphorus which were produced by thermonuclear processes inside second generation stars like our sun. Further, the Universe is expanding constantly, and it is expanding at a particular speed. The speed of its expansion has also been very much responsible for the formation of molecules of which we are formed and a little variation in it could have made emergence of life impossible. Another remarkable coincidence cited by Gribbin and Rees is the specific energy level of carbon-12. Sir Fred Hoyle (1965) predicted that carbon-12 should have a particular energy level, about 7.6 MeV which is nearly equal to the combined energy of helium-4 and berellium-8 as these two molecules probably underwent a resonance inside stars to form carbon-12 molecules. However, this energy level of carbon-12, as calculated by Hoyle, is 4% higher than the earlier calculations. But, to the astonishment of everyone, experiments have proved that Hoyle's prediction is correct. So, this particular energy level of carbon-12, 4% higher than what it should be by routine calculations, was a great coincidence that made synthesis of carbon inside stars, and thereby creation of life on this planet, possible. Another coincidence worked simultaneously that preserved this carbon stock, to be used later for creation of life. The next element which could have formed in stellar nucleosynthesis was oxygen-16, by union of carbon-12 and helium-4. But here the resonance did not work because oxygen-16 has 1% less energy than the combined energy of carbon-12 and helium-4. This coincidence ensured that all the carbon-12 synthesized in stars did not get processed into oxygen-16. Had this occurred, there would not have been enough carbon to create carbon based life forms. 'This combination of coincidences, just right for resonance in carbon-12, just wrong in oxygen-16, is indeed remarkable. There is no better evidence to support the argument that the Universe has been designed for our benefit – tailor made for man', conclude Gribbin and Rees (1989).

Or a Chance Event?

The above account indicates towards the inevitability of life in this Universe, i.e., the Universe was designed for creation of life and life was determined to evolve in this Universe. However, there is another school of authors, viz. Luisi (2003), Monod (1971), Jacob (1982) and Gould (1989) etc who support an alternative to this deterministic view – contingency. 'Contingency is the outcome of a particular set of

concomitant effects that apply in a particular space-time situation and thus determines the outcome of a given event' (Luisi, 2003). According to this view, the existence of life on this planet is by 'chance' or is a 'random event'. The proponents of this view hold that if the outcome of a series of events is not the same when the same series of events is repeated, this outcome is a chance or a contingency. Gould (1989) has explained biological evolution on the basis of contingency in this way—'run the tape again and the first step from prokaryotic to eukaryotic cell may take twelve billion years instead of two' (Luisi (2003). It implies that if the life history of earth is repeated, it is not necessary that man will be here after 4-5 billion years, or he will be here at all at any time.

Luisi (2003) discusses contingency in following words. 'A car accident occurs due to accumulation of many independent factors- like car speed, the road conditions, the state of the tyres, the alcohol consumption of the driver, etc. Though each of these independent factors is a deterministic event, but it carries an unknown statistical weight, and therefore, all these factors make the complete accident unpredictable- a chance event. Change the contingent conditions and the final result would be quite different- it may happen a week later, a month later or never.' Now let us think about the above phenomenon another way. If all the factors in the above case are indicating towards a probable accident, for example, tyres are bad, road is bad, speed is high, driver is drunk, and then there is a high probability of an accident and very low probability of a safe journey. So now, if the accident occurs, whether it will be called a chance event or a deterministic event is debatable. But in my view, it is almost determined. The time of the accident is of course a chance event. However, if all the above conditions are good, or nearly good, the probability of accident is very less. But even then an accident is probable. If it occurs now, it is purely a chance event- a contingency.

Now the question arises that whether life originated in a set of conditions that were extremely favorable for it, or in a set of conditions that were not very favorable for it. If it occurred in former conditions, it is more like a deterministic event, though chance would certainly have played its role in determining the time of origin. It was a contingent event if it occurred in latter conditions. Let us take another example of a 'snake and ladder' game. Our every move in the game is a chance- it can lead us to a snake, to a ladder or simply few steps ahead. Thus, on our way to the destination, we are encountered at many places by negative contingencies (snakes) as well as positive contingencies (ladders). But somehow, sooner or later, we reach there. If we play the game again, we shall again reach the destination, though the number of moves and the course we shall take will be quite different from the previous game. Thus, if we have the dice and we are allowed any number of moves, there is little doubt in reaching the destination- many contingencies summing up to create a deterministic event. I shall like to discuss one more analogy. Let us suppose there is a young aspiring student aiming to achieve a very high goal in his life. He is sincere about his goal, has the right atmosphere and capabilities and is putting all his might into realizing that goal. He is highly successful at all of his academic as well as professional examinations. He enters his cherished career and finally is successful in achieving his goal. There is no doubt that some amount of chance has favored him at each step in his life, even then, his success will be said to be a deterministic event, not shaped by chance alone.

Conclusion

Life has performed in a similar way during its long career. It has been highly successful at almost all steps and, consequently, has resulted in evolution of intelligent life. The journey from molecules to man could

not have relied simply on the mercy of chance; rather chances might have helped the special properties of the Universe in creating life. 'Chance favors the prepared mind', goes the adage. Experiments have been performed to test the role of contingency and determination in evolution. Losos *et al.*, 1998 studied the evolutionary radiation of Anolis lizards on four islands of the Greater Antilles and found the same set of ecomorphs on all four islands. They concluded that the adaptive radiation in similar environments can overcome historical contingencies to produce strikingly similar evolutionary outcomes. Hendry and Kinnison (2001) have opined that in general, microevolution seems to be driven largely by deterministic mechanisms, but contingency plays a role in (1) determining whether or not suitable conditions are present for evolution to proceed and (2) guiding the precise manner by which evolution proceeds. Thus, life is probably a result of both determinism and contingency. While the former decided the conditions required to create life, the latter decided the time of its creation. Taylor and Mc Phail (2000) are also of the opinion that contingency and determinism both act together to promote evolutionary divergence and they have showed it in sympatric sticklebacks. While talking about determinism, one may ask why this Universe was designed the way that was most favorable for creation of life. Probably this problem arises because we assume that life and Universe are two separate entities. Let us remove this dichotomy between Universe and life for a while, unite them, and the problem will probably disappear. Because then not only the Universe is designed for creation of life, life is also designed to fit into this Universe. Life is a part of this Universe, a product of this Universe, or better to say- a flower or fruit, though a rare one, of this Universe. Both are complementary to each other as both are part of a 'unity'.

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