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Short Communication

The Rareness or Abundance of Life in the Universe

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ABSTRACT

The most important issue in the new scientific discipline of astrobiology is how prevalent life is in the Universe. Life could be so rare as to be found in only one solar system (ours) or life could be so abundant as to be found in every solar system in the Universe. Most likely, life as we know it will be found in a number of solar systems in the Universe, but whether this number is small or large (whether life is rare or abundant) is yet to be determined. We will begin to get a handle on this issue only when we have reliably mastered the astrobiological science of biosignature detection on extraterrestrial planets.

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SHORT COMMUNICATION

Rareness

The chemical complexity of life as we know it (C_L) is so extraordinarily great that we still do not understand how prebiological monomers condensed to form informational biopolymers on the Primitive Earth roughly 4 billion years ago. Biochemistry is so vastly complex that no organic chemist could have predicted its structure from knowledge of the biomonomers alone. We have been unable to duplicate in the laboratory Nature's creation of life from its constituent elements. For such reasons, the rareness of life in the Universe (R_L) must be exceedingly great and the number of planets containing life in the in the Universe (N_L) must be very small.

If we let R_L=Rareness of Life in the Universe, A_L=Abundance of Life in the Universe, C_L=Complexity of Life in the Universe, and S_L=Simplicity of Life in the Universe, then RL and AL are the inverse, or reciprocals, of each other, S_L and C_L are the inverse, or reciprocals, of each other, RL is proportional to C_L, and A_L is proportional to S_L.

The organism with the greatest SL and the least C_L on the Primitive Earth was probably LUCA (the Last Universal Common Ancestor). However, on the present Earth, the organism with the greatest S_L is probably mycoplasma and the organism with the greatest C_L is undoubtedly man.

ABUNDANCE

As for arguments supporting the abundance of life in the Universe, they start with the observation of hundreds of billions of galaxies in the Universe. But let's be conservative and suppose there are one hundred billion (10^{11}) galaxies in the universe. Then let us suppose that each galaxy contains one hundred billion (10^{11}) stars. Then we can say that there are 10^{22} stars in the Universe. Let's say that each star has ten (10^1) planets. Then there are 10^{23} planets in the Universe. Of the 10^{23} planets in the Universe, it is reasonable to assume that one tenth (10^{-1}) of them are Earth-like, and therefore capable of biogenesis. That is, there are 10^{22} planets in the Universe that are biocompatible.

At this point we have to make an intuitive judgment about how likely it is that biogenesis will take place on a biocompatible planet. Well, it only took about 200 millions years for life to form on the Primitive Earth as soon as our planet cooled down enough to allow the accumulation of organic molecules. This short, early biogenesis suggests that life is easy and therefore abundant and widespread in the Universe. Whole planets provide immense amounts of space, time, molecular ingredients, and energy for Nature's experiments in combinatorial chemistry,

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much more so than any numbers of combinatorial chemistry experiments to be performed by scientists in laboratories, so far.

Taking into account the extraordinary chemical complexity and difficulty of synthesizing life in the laboratory as indicated above, let us assume that biogenesis rarely takes place on biocompatible planets. That is, let us assume that biogenesis never takes place on the overwhelming majority of earth-like planets. For example, let us assume that only one out of a million (10^6) biocompatible planets ever gives rise to life. We should then reasonably expect to find life on $10^{22} \times 10^{-6} = 10^{16}$ of them. That is, we should expect roughly one thousand trillion planets containing life in the Universe. Thus, $NL=10^{16}$. There could be approximately about a quadrillion life-bearing planets in the Universe.

A suggested conclusion from these numbers is that no matter how complex life is in the Universe, it will be quite abundant and widely distributed throughout the Universe. Consequently, when it comes to life in the Universe, it is possible that numbers swamp even complex chemistry in favor of abundance. But we do not know if that is what actually happens in the Universe. Consequently, the issue of the rareness or abundance of life in the Universe remains an open question.

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