An equation to quantify the origins of life on other planets

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(Phys.org)—A pair of researchers, one with the Columbia Astrobiology Center in New York, the other with the University of Glasgow in the U.K. has come up with a mathematical equation that when solved is meant to offer a means for estimating how often life begins on other planets. In their paper published in *Proceedings of the National Academy of Sciences*, Caleb Scharf and Leroy Cronin describe their equation, how they came up with it and why they believe it might become more useful as scientists learn more about the true nature of other planets and solar systems.

Back in the 1960's, an astronomer named Frank Drake came up with a formula for estimating the likely number of alien civilizations that might be capable of transmitting radio signals in such a way as to be recognizable by receivers here on earth. That equation, named quite naturally the Drake Equation has been the unofficial standard-bearer for half a century, despite it having no solution because some of the parameters are still unknown. The same holds true for the new equation developed by Scharf and Cronin, but the results given should the unknowns ever be discovered would offer a different sort of answer than Drake was looking for.

To build their formula, the duo came up with several parameters to solve for abiogenesis, which is the likelihood of an event occurring that leads to life beginning, they included the number of possible building blocks, the mean number of such blocks per possible organism, the availability of building blocks that might exist during a given time period, expressed as a fraction and the probability that the existence of the building blocks would actually lead to life starting in a given unit of time. It looks like this:

$$N_{abiogenesis}(t) = N_b \cdot 1/n_o \cdot f_c \cdot P_a \cdot t$$

In essence the formula is meant to suggest that the probability of life beginning on a given planet is very likely connected to whether there are building blocks available on a given planet, and how much of them there might be. As more is learned by space researchers it is hoped that the formula could help narrow down search targets by offering a statistical probability of success for a given planet. The researchers note that the building blocks available do not necessarily have to be of the type that led to life beginning on our planet. They also suggest that implied in the formula is the likelihood that life beginning events are more likely to occur in solar systems where there are multiple planets, which allow for an opportunity to share materials that could lead to building blocks.

More information: Quantifying the origins of life on a planetary scale, *Proceedings of the National Academy of Sciences*, www.pnas.org/cgi/doi/10.1073/pnas.1523233113

Abstract
A simple, heuristic formula with parallels to the Drake Equation is introduced to help focus discussion on open questions for the origins of life in a planetary context. This approach indicates a number of areas where quantitative progress can be made on parameter estimation for determining origins of life probabilities, based on constraints from Bayesian approaches. We discuss a variety of "microscale" factors and their role in determining "macroscale" abiogenesis probabilities on suitable planets. We also propose that impact ejecta exchange between planets with parallel chemistries and chemical evolution could in principle amplify the development of molecular complexity and

abiogenesis probabilities. This amplification could be very significant, and both bias our conclusions about abiogenesis probabilities based on the Earth and provide a major source of variance in the probability of life arising in planetary systems. We use our heuristic formula to suggest a number of observational routes for improving constraints on origins of life probabilities.