

Probability formula for life

Source: <http://sci.tech-archive.net/Archive/sci.bio.evolution/2007-06/msg00104.html>

- *From:* dkomo <dkomo871@xxxxxxxxxxxxx>
 - *Date:* Mon, 25 Jun 2007 17:12:11 -0400 (EDT)
-

If there are 300 billion stars in an average galaxy and 100 billion galaxies in the observable universe, the total number of stars is 3×10^{22} . Suppose we wanted to know to a certainty of 99.9999% that life has formed at *least* once on some planet other than earth at one of these stars. What would be the minimum average probability of life forming at any of these stars? We can find a simple formula to answer this question.

Let p_a = the average probability of a star supporting life

P = the probability of at least one other star in the universe with life

$Q = 1 - P$ = the probability of no other stars than the sun with life

We want to find p_a given $P = 0.999999$ (a certainty of 99.9999%)

The probability of a star *not* supporting life is

$$1 - p_a$$

So the probability of no other stars in the universe supporting life is

$$(1). (1 - p_a)^{(N-1)} = Q \text{ where } N = 3 \times 10^{22}$$

The -1 results because we're excluding our own sun, but N is so large that $N-1$ is equal to N for practical purposes.

Taking the natural logarithm of both sides of equation (1), substituting N for $N-1$, and dividing through by N we get

$$(2). \ln(1 - p_a) = \ln Q / N$$

Using the power series expansion for \ln ,

$$(3). \ln(1 - p_a) = -p_a - p_a^2 / 2 - p_a^3 / 3 - \dots$$

Since p_a is small, we can neglect all terms but the $-p_a$ term.

Probability formula for life

So the final equation is

$$(4). p_a = -\ln Q / N$$

Now, given $P = 0.999999$, $Q = 1 - P = 10^{-6}$

$$p_a = -\ln(10^{-6}) / (3 \times 10^{22}) = 4.61 \times 10^{-22}$$

This means that if the average probability that a star in the universe contains a planet with life is no less than 4.61×10^{-22} , we can be 99.9999% certain that the universe contains *at least* one star (other than our sun) with life.

Those are pretty good betting odds.

Note that the above analysis ignores *when* life develops at a star. The analysis is not constrained to extant life. If life developed only once at some other star 200 million years ago, then disappeared, that is an example of a successful life event.

--dkomo@xxxxxxxx