

Planets Outside Our Solar System: Is there life on other worlds?

The Drake Equation

•Materials

calculator

•Introduction

Are we alone? For the first time in history, astronomers have discovered planets orbiting stars beyond our own Sun. In fact, planetary systems seem to be widespread in the universe. Is there life, intelligent or otherwise, in any of these alien solar systems? No one yet knows. But ours may be the first generation to detect a sign of life beyond Earth. What will it mean if we find out that we are not alone?

At first, "Is there life on other worlds?" seems a simple question to answer. However, it quickly becomes a complex web of issues. What is life, anyway? How does it begin and evolve? What conditions can life tolerate? What makes a planet habitable? How do we look for and identify extraterrestrial life? To attempt to resolve these kinds of questions, astrobiologists draw on many branches of science and employ many research strategies, such as fieldwork, laboratory research, telescopic observation, and exploration with spacecraft.

Though we have not found any examples of extraterrestrial life, comparisons with certain kinds of life on Earth suggest that potential habitats for extraterrestrial life, and maybe life itself, do indeed exist. However, contrary to popular notions, if extraterrestrial life is found in our solar system, it will most likely be bacteria-like.

In 1961, the astronomer Dr. Frank Drake suggested an organized framework for thinking about life in the galaxy. Known as the Drake Equation, it provides a way to estimate the number of worlds within our Milky Way galaxy that have intelligent life and whose radio transmission should be detectable. Drake identified a sequence of eight terms to help people think about what must occur before a world can be

inhabited by a civilization with radio technology. This activity uses Dr. Drake's framework to have you consider the implications of each term and make your own estimates of life in the Milky Way galaxy.

Because we are unsure whether there is life out there, let alone intelligent life with which we can communicate, there is no correct solution to the equation - the value of each factor is open to interpretation.

•Procedure

To find out your estimate of the number of worlds in the Milky Way galaxy that have intelligent life that we can detect using radio technology, fill out the chart on the following page. Multiply the eight terms. Don't forget to convert percentages to numbers.

•Questions

- 1) What is your final answer?
- 2) Based on your estimates, how good are our chances of hearing from intelligent extraterrestrials?
- 3) How does your answer to 2) compare with what you thought before you began the activity?
- 4) What if your answer to 1) were less than one? What would that mean in terms of our existence here on Earth?
- 5) When making estimates, in which terms did you have the most confidence? The least? Why?
- 6) Are you more optimistic or more conservative when it comes to thinking about extraterrestrial life with radio technology in the Milky Way galaxy? Why?
- 7) How could you adjust the estimates in the equation to have it come out so that Earth is the only planet in the Milky Way galaxy with radio technology?
- 8) What would your reaction be if we discovered microbes on another planet? Plants? Insects? Mammals? Intelligent life?
- 9) If microbial life were discovered on another planet, what implications might the discovery have?

Term	Background	Conservative Estimate	Optimistic Estimate	Your Estimate
1. The total number of stars in the Milky Way Galaxy	These numbers are based on observations of the stars in our galaxy and of other galaxies we believe to be like our own. Most scientists believe the number of stars to be 400 billion.	100 billion	600 billion	
2. The percentage of stars that are appropriate	Many scientists believe that a star has to be like our Sun. Only about 5% of the stars in our galaxy are sun-like stars, though about 10% are closely related, either slightly warmer or slightly cooler. About 50% of stars exist in binary or multiple systems, which many scientists feel make them inappropriate.	0.05%	45%	
3. The average number of planets around each appropriate star	Appropriate stars may not have planets circling them. We have only just begun detecting extra-solar planets, so we don't really know how common they are.	1	10	
4. The percentage of planets within a solar system that are habitable	Our only example of this term is our own solar system. Could Earth be the only habitable place in our solar system? Is our system typical? Remember that if one system has no habitable planets and another has four, the average would be two per system.	10% On average, there is one habitable planet in every system	50% Half the planets in are habitable	
5. The percentage of habitable planets that develop life	Having a planet that is appropriate for life doesn't necessarily mean that life will arise. No real data are available to help us estimate this term. Earth is the only planet on which we know there is life. However, bacterial life existed on Earth shortly (geologically speaking) after its formation, possibly indicating that the development of life is easy. Many scientists believe that whether or not life arises depends on many factors.	0.000001% Life is a rare accident that is unlikely to happen elsewhere	100% Life will arise if conditions are appropriate	
6. The percentage of planets with life that develop intelligent life	On Earth, humans developed intelligence, apparently as an evolutionary advantage. However, this term depends on how you define intelligence. Are dolphins, gorillas, octopus, and ants intelligent? Furthermore, single-celled life existed on Earth very early, and multicellular life took 2.5 billion years to form (a very long time, geologically speaking). Maybe the development of complex life, let alone intelligent life, is unusual.	0.0001% or less Only one in a million planets with life will develop intelligent life	100% Any planet with life will develop intelligent life	
7. The percentage of intelligent life that develops radio technology	Communication with intelligent extraterrestrials requires that we hear from them. Given the vast distances of space, they would probably send signals that travel at the speed of light, such as radio waves. On Earth, humans have only just developed radio technology, so possibly this term should have a low value. But, we did eventually develop radio technology, so maybe this is true of all intelligent beings.	0.0001% or less Only one in 1,000,000 planets with intelligent civilizations will develop radio technology	100% All intelligent life will develop radio technology	
8. The percentage of "current" civilizations having radio technologies	Will an extraterrestrial's signals overlap with the lifespan of the receiving civilization? Extraterrestrials that sent signals a hundred thousand years ago from a world a hundred thousand light years away would still overlap with us, even if they died out long ago. So, how long do civilizations with radio technology last? A high level of technological development could bring with it conditions that ultimately threaten the species. Or maybe, once a society has radio technology, it may survive for a long time. Finally, radio signals may give way to more advanced, less noisy technologies such as lasers. No one would hear us then!	0.0001% or less Only in a million civilizations with radio technology will develop it in time to detect signals from another civilization	10% One in ten civilizations with radio technology will develop it in time to detect signals from another civilization	
TOTAL	Planets in our galaxy to listen for			

10) What do you think is the most abundant life form on Earth?

11) If life exists elsewhere, what do you think it will look like?

12) Can you think of any other terms that might affect your estimation of life in the universe?

•Further Investigation (Optional)

Several space telescopes have recently (2005) made some direct images of extra-solar planets. Discuss these findings and the current status of extra-solar planet detection.

[2-5 points]