Search for Extra-Terrestrial Intelligence (SETI)
By Paul Lewis

"How can we estimate the number of technological civilizations that might exist among the stars? While working as a radio astronomer at the National Radio Astronomy Observatory in Green Bank, West Virginia, Dr. Frank Drake (now Chairman of the Board of the SETI Institute) conceived an approach to bound the terms involved in estimating the number of technological civilizations that may exist in our galaxy. The Drake Equation, as it has become known, was first presented by Drake in 1961 and identifies specific factors thought to play a role in the development of such civilizations. Although there is no unique solution to this equation, it is a generally accepted tool used by the scientific community to examine these factors." (SETI, 2008)

This 'solution' to the Drake equation is purely my personal view. In that respect it is neither right nor wrong, but simply a reflection of my view of the Universe. Every person that works through the equation will come up with a different answer. However, it is useful as a means of stimulating debate about the question of ET. Try it yourself.

The Drake equation:

$$N = RF_pN_eF_lF_iF_cL$$

where:

***R* = number of suitable stars -- stars like the sun -- that form in our galaxy per year.**

There are two ways of looking at this:

1. Assume that the number of stars in the galaxy remains about the same i.e. number of stars that die per year is equal to the number of stars born per year. Stars die in a number of ways, such as becoming supernovae, black holes, neutron stars or white dwarfs. Since we are only concerned with Sun-like stars, we are really concerned with white dwarfs, which can be identified by an associated planetary nebula. It is very rare for new planetary nebulae to be reported, suggesting that the rate of formation is low. Similarly supernovae have a low rate of formation, with only a few reported in any year. Although we cannot see most of the galaxy, in our part star death is low. This suggests that star birth is similarly low, and even lower if we only consider Sun-like stars. It is likely to be in the tens per year, rather than the hundreds.
2. The Milky Way is about 12 billion years old, with about 100 billion stars. On average, this gives a star formation rate of $100\times10^9/12\times10^9 = 8.5$ stars per year (Jones and Lambourne, 2004). If we assume only half of these can be considered suitable, this gives a star formation rate of 4 per year, which seems low compared to the previous paragraph. Other sources can provide figures that are double the number of stars i.e. 200 billion (some estimates go even higher, but since these are low mass stars, they are of no interest to us), so a value of 10 per year for *R* seems reasonable.

   $$\boxed{R = 10}$$

   Jones, M. H. and Lambourne, R. J., ed., 2004, *An Introduction to Galaxies and Cosmology*, The Open University and Cambridge University Press.

F_p = fraction of these stars that have planets.

Stars are formed from clouds of gas and dust. In any situation, it is reasonable to assume that there will always be a dust and gas cloud left over when a protostar has formed. This cloud can form the basis for a planetary system. It seems reasonable to assume that this will occur in most, but maybe not all, cases of star formation, suggesting maybe in 75% of cases.

$$F_p = 0.75$$

N_e = number of Earth-like planets -- meaning planets that have liquid water -- within each planetary system.

Planets that have liquid water will normally be within the Habitable Zone. Given the size of a planetary system (taking the Solar System as an example) the Zone is not a large part of it. Although there are two or three planets in the Solar System Habitable Zone (Mars is borderline), only Earth is comfortably in the Zone. Therefore the number of earth-like planets is about one.

$$N_e = 1$$

F_l = fraction of Earth-like planets where life develops.

Since the origin of life is a chemical process, there is no reason why it should not occur. This is particularly so with more recent planets, which will have benefited from a larger chemical mix as a result of a more diverse range of elements produced in later generation stars. Therefore this value is likely to be close to one.

$$F_l = 0.9$$

F_i = fraction of life sites where intelligent life develops.

A number of species on Earth have developed intelligence, such that their decisions are governed by thought rather than simply instinct. One view may be that if different creatures of the same species demonstrate different personalities, then they have a level of intelligence. On Earth many species of animals have developed some form of intelligence and there does not seem to be any bar on this occurring. Intelligence improves the chances of survival and hence may well be favoured by natural selection, up to a certain point. There are species much older than humans e.g. crocodiles, which have not developed higher intelligence because there was no benefit for them in survival terms to do so.

If higher forms of life develop, then it is likely that so will a level of intelligence, given sufficient time. However, it has taken about half of the Sun’s life for this to occur.

$$F_i = 0.75$$

F_c = fraction of intelligent life sites where communication develops.

Where intelligence has evolved, there is normally e level of communication, from the barking of a dog to the chirping of crickets. In this case we need to talk about higher communication, which involves the ability to exchange and store information, either biologically or otherwise e.g. written. Of all the millions of species on Earth, so far only one has managed this. As previously noted, this has taken approximately half of the home star’s lifespan. It therefore does not seem very likely.

$$F_c = 10^{-8}$$

L = lifetime (in years) of a communicative civilisation.

As a species, we have no experience of this. Furthermore the means of communication may change to a method that is incompatible with previous technologies. However, if the methods used represent fundamental technologies, it is possible that they will persist. Some of our most important technologies e.g. fire, the wheel and the lever, are also amongst our oldest and have been around for several thousand years or more. Therefore changes in technologies may not be an issue. It is simply the life of our civilisation that is important.

Recently we have developed the means to destroy ourselves, but have not actually carried this out. It is quite feasible that in the near future, part of our civilisation (i.e. one or more countries) will be destroyed. However, most of our civilisation will persist, since we have evolved the skills to work together when necessary to defeat a common enemy. A good example of this was the Second World War. There is no reason why the life of a cililisation should not be in thousands of years.

$$\boxed{L = 10^5}$$

***N* = number of communicative civilisations within the Milky Way today.**

$$N = RF_p N_e F_l F_i F_c L$$

$$N = 10 \times 0.75 \times 1 \times 0.9 \times 0.75 \times 10^{-8} \times 10^5$$

$$N = 5.06 \times 10^{-3}$$

This result suggests that communicative civilisations within the Milky Way are extremely unlikely. We are therefore alone in the Universe. It raises the question as to whether we are simply an anomaly, rather than the future.

Reference

SETI (2008), *Drake Equation*, SETI Institute, available from http://www.seti.org/Page.aspx?pid=336 [accessed 22 June 2009]