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Does intelligent life exist beyond our planet? An exercise in estimation and problem solving

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Does intelligent life exist beyond our planet? An exercise in estimation and problem solving

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ABSTRACT In this activity, students use the famous Drake equation to estimate the probability of intelligent life existing elsewhere in our galaxy. Many students (some fascinated by the possibility of life beyond our planet) will be interested in this activity once they realise that the computer can do the difficult mathematics. However, the calculations are actually straightforward enough to be done with paper and pencil.

The activity described here is suitable for use in science lessons or as the basis of a STEM club enrichment project. It is based around the famous probability equation developed by Frank Drake, an American astronomer and astrophysicist who was born in 1930. He is best known for his pioneering work in the quest to search for extraterrestrial intelligence and was a founder member of the SETI programme (www.seti.org).

Drake has spent a large part of his working life honing and developing an equation that estimates the number of 'intelligent' life civilizations in our galaxy. At first sight, the Drake equation looks quite daunting:

$$N = R \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

where:

R is the number of stars in the Milky Way galaxy; astronomers believe that this number falls somewhere in the range of 100–400 billion.

f_p is the fraction of stars that have planetary systems; current estimates are that this lies between 0.2 (20%) and 0.5 (50%) of star systems.

n_e is the number of planets suitable for life within a star system; this is thought to be somewhere between 1 and 5.

f_l is the proportion of planets where life actually arises; this is thought to have a range between 0.001 (0.1%) and 1 (100%).

f_i is the proportion of planets where intelligent life arises; this is also estimated to have a range between 0.001 (0.1%) and 1 (100%).

f_c is an estimation of the proportion of planets with communicating civilizations; again, for this exercise, it is considered to have a range between 0.001 (0.1%) and 1 (100%).

L is an estimate for the proportion of a planet's life that it is inhabited by a communicating civilization; this is thought to be somewhere between 0 and 0.005 (0.5%).

So, by working through the factors, we come up with an answer for N, where N is the number of communicating technological civilizations in the Milky Way galaxy.

The equation looks complex but the operations involved in solving this equation are those of lower secondary school mathematics.

A set of classroom resources, including a *PowerPoint* file, an *Excel* spreadsheet and structured student materials, are available to download to support this activity (www.ase.org.uk/documents/drake-equation/). The resources were developed by the Centre for Science Education team at Sheffield Hallam University, as part of the national STEM Subject Choice and Careers Project.

Teaching points covered by the Drake equation that relate to mathematics include:

- discussion and understanding of probability – many of the components of the Drake equation are decimals based on probabilities, and students will need to choose and justify suitable values to assign to these probabilities;
- knowing and using the relationship between percentages and decimals;

- understanding the effect of multiplying by a number between 0 and 1 – students will use calculators, paper and pencil methods, and a spreadsheet to evaluate the Drake equation using a range of values;
- substituting into an equation and understanding the use of a symbol to represent an unknown.

The numbers used in the Drake equation are either very large or very small. In mathematics, students are expected to practise pencil and paper methods of performing calculations with numbers that are multiples of 10. The Drake equation provides both great context and opportunity to do this, making it a truly cross-curricular activity. Figures 1, 2 and 3 show examples of materials available for download.

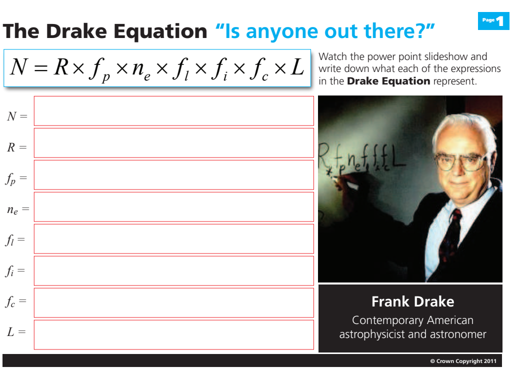


Figure 1 Frank Drake illustrating his equation

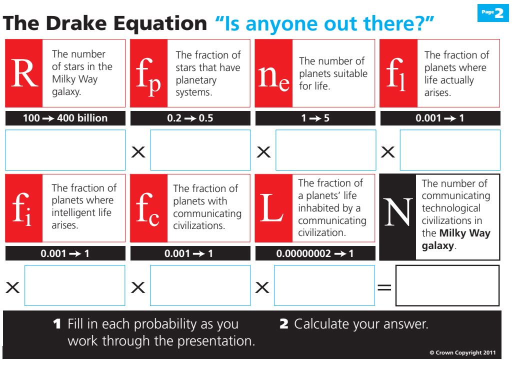
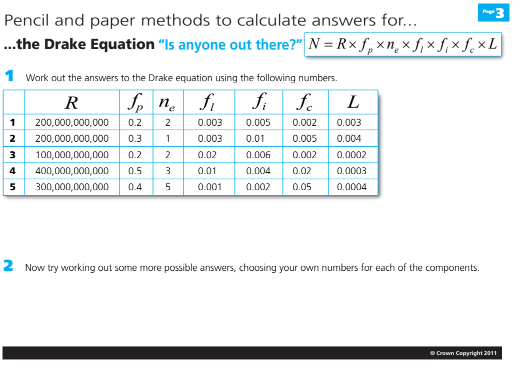


Figure 2 Template for inserting selected figures for the Drake equation



	R	f_p	n_e	f_l	f_i	f_c	L
1	200,000,000,000	0.2	2	0.003	0.005	0.002	0.003
2	200,000,000,000	0.3	1	0.003	0.01	0.005	0.004
3	100,000,000,000	0.2	2	0.02	0.006	0.002	0.0002
4	400,000,000,000	0.5	3	0.01	0.004	0.02	0.0003
5	300,000,000,000	0.4	5	0.001	0.002	0.05	0.0004

Figure 3 Possible values to use in sample calculations

Calculating the chances of intelligent life existing beyond the Earth

The Drake equation is $N = R \times f_p \times n_e \times f_l \times f_i \times f_c \times L$. For a worked example, let us assume the following values:

R (stars in galaxy) $= 1.0 \times 10^{11}$

f_p (planetary systems) $= 0.2$

n_e (planets suitable for life) $= 2$

f_l (planets where life actually arises) $= 0.001$

f_i (intelligent life arises) $= 0.008$

f_c (communicating civilizations) $= 1$

L (planet's life that it is inhabited) $= 0.0001$

Therefore $N = 32$.

The number of technological civilizations capable of communicating in the Milky Way is 32, based on the assumed values for the factors in the Drake equation. Why have we not yet been successful in communicating with other civilizations? Or are some of these assumed values inaccurate?

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