Cosmic Safari Math Rotation

Are there other civilizations out there… Or are we alone?

Are there civilizations out there listening? We don't yet know the answer, but Dr. Frank Drake, president of the SETI Institute, came up with an equation that allows us to make an estimate by multiplying seven quantities related to the prevalence of life.

Since its introduction in 1961, this tool has come to be known as "The Drake Equation."

The Drake Equation is quite complex.

$$N = R \times fp \times ne \times f1 \times fi \times fc \times L$$

Let's define each term you see above:

N =

R =

fp =

ne =

If you download this file, you will be downloading the lesson plan and teacher notes (answers from actual scientists) to solving this equation, as well as receiving basic background information on Dr. Drake and this equation.

f1 =

fi =

fc =

L =

Making Complex Estimates

Before we use this equation to estimate the number of intelligent civilizations in the Milky Way, let's use the equation to make a more "down to Earth" prediction!

There are many instances in science where estimation is much more useful and efficient than counting. In particular, estimation techniques are important when analyzing a system for which counting is not actually possible. Complete the following estimation task.

PREDICTION: How many females in the 7th grade who are on our team with long hair that is brown or dark brown and have a hair tie with them RIGHT NOW and it is holding their hair in a messy ponytail? ____________________

TASK: To check your prediction, complete the following table by estimating the:

Variable	Estimated Value *(fractions as decimals)*	Notes
n - total number of students in your school		
f_f- **fraction of females** in your school (written as a decimal)		
$f_{f,7}$ - fraction of those females in **7th grade**		
$f_{f,7,O}$ - fraction of those females in 7th grade **who are on our team**		
$f_{f,7,O,L}$ - fraction of those females in 7th grade who are on our team **with long hair**		
$f_{f,7,O,L,B}$ - fraction of those females in 7th grade who are on our team with long hair **that is brown or dark brown**		
$f_{f,7,O,L,B,H}$ - fraction of those females in 7th grade who are on our team with long hair that is brown or dark brown and **have a hair tie *with* them RIGHT NOW**		
$f_{f,7,O,L,B,H,M}$ - fraction of those females in 7th grade who are on our team with long hair that is brown or dark brown and have a hair tie with them RIGHT NOW and it is **holding their hair in a messy ponytail**		
F - Fraction Of Total Population *(multiply all of the above fractions: f-values)*		
T - Number of People at Your School Meeting The Criteria: product of fraction of total population **F**, and the total school population, **n** *(multiply F from above and n from top)*		
CLASS AVERAGE, Tavg		

Finding the number of Possible Civilizations out there…

Using the DRAKE EQUATION!

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

In the previous activity, we estimated the number of students that had particular characteristics. In this activity, we will use the same estimation techniques to discover the number of existing extraterrestrial civilizations that possess the technology to communicate beyond their home planet. Your task is to complete the table below and use those values to solve the Drake Equation in order to estimate the number of intelligent civilizations in the Milky Way.

Variable	Estimated Value *(fractions as decimals)*	Notes
R - Number of target stars in the galaxy that: • are second generation stars with heavy elements • are hot enough to have a large habitable zone • have a long enough lifetime for life to develop	**R** =	
fp - Fraction (percentage) of those stars with planets or planet systems. *Write as a decimal!*	**Fp** =	
ne -Number of "Earth-like planets" in a planetary system that are at the right temperature for liquid water to exist (in the habitable zone).	**Ne** =	
fl - Fraction (percentage) of Earth-like planets where life actually develops.	**Fl** =	
fi - Fraction (percentage) of Earth-like planets with at least one species of intelligent life	**Fi** =	
fc - Fraction (percentage) of Earth-like planets where the technology to communicate beyond their planet develops	**Fc** =	
L - "Lifetime" of communicating civilizations (years) - Note: This number must be divided by the age of the galaxy, 10 billion years, when you make your final calculation.	**L** =	
N - Number of communicative civilizations	**N** =	

Reflection/Discussion Questions about the Hair Tie Equation

$$T = n \times (f_f \times f_{f,7} \times f_{f,7,O} \times f_{f,7,O,L} \times f_{f,7,O,L,B} \times f_{f,7,O,L,B,H} \times f_{f,7,O,L,B,H,M})$$

A. What value of T did you determine and how did it compare with the class average?

B. Give specific reasons why your value was different than the class average.

C. Predict how the calculation will change if you observe blondes instead of brunettes. Check your prediction by performing the necessary calculation.

D. Explain how the value of T would be different if you changed your definition of long hair.

E. Suppose that you were making this estimate for an all-female school where lunch hair is required to be out of your face. How would your estimate change? Why?

Reflection Questions about the Drake Equation

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

A. What value did you get for the number of civilizations?

B. How does the value change if you double the lifetime of communicating civilizations?

C. How does the estimate change if we discover that only 1/3 of Sun-like target stars have planets?

D. How would you change your estimate if we discovered that early life developed on both Venus and Mars?

H. How many intelligent, communicating species in the galaxy do we actually know about? What then is the actual minimum value for N. (Hint it is not zero.) Explain your reasoning.

CHALLENGE PROBLEM: *Scientists recently discovered a massive gas giant planet orbiting the star 51 Peg. This planet orbits in the star's habitable zone (where liquid water can exist). Describe how this finding might change your estimate.*