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The Drake Equation

An Exercise in "Fermi Thinking"

Spread around the classroom are a series of “clues” that will help you answer the following question:

Estimate how many intelligent, communicating civilizations exist in the universe.

Step 1:
Before turning the page, picking up a clue, or looking up anything on the internet, spend 5 minutes brainstorming with your lab partners as to what information you will need to answer this question. What factors are likely to come in to play? List as many as you can think of in the space provided below.

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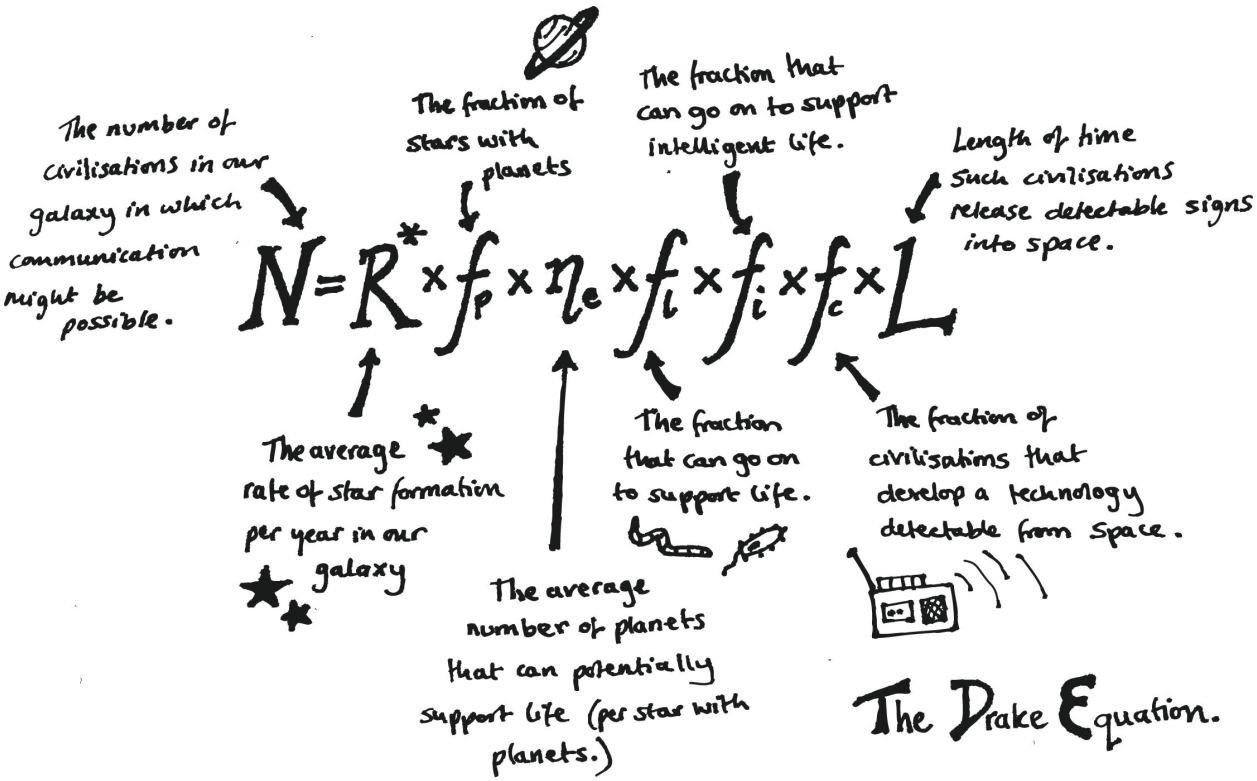
Fortunately, a famous astronomer named Frank Drake came up with a quantitative means of estimating the answer to this question, with a number of different multiplicative factors. The classical version of this equation is:



You may note that Drake's Equation is a means of estimating the number of intelligent, potentially communicating civilizations **in our own galaxy**, but today you're going to modify this framework slightly to estimate the number of intelligent, communicating civilizations in the universe as a whole, so we will follow the following equation:

$$N = n_s/T \times f_p \times n_h \times f_l \times f_i \times f_c \times L$$

where the only two factors that are different relative to the original equation are:
n_s: the number of stars in the universe
T: The lifetime of an average star

Each "clue" spread around the classroom contains some real data that will help you make an estimate for each factor. Your group can pick them up in any order. Each one asks you to work out your estimate for the factor below the clue(s), and you will need to staple all of those (in order please) to this lab at the end.

As the equation continues, your answers will become increasingly speculative. For several of the later factors, we only have one real data point to go on, though you should think some based on what you've learned over the course of the last unit about how typical earth is likely to be as an example. Your estimate for these later factors doesn't have to be the

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Earth value, but you should justify your choice based on an explanation of how typical (or not) you think Earth is.

Like the other Fermi problems we did earlier in the class, there is no one right answer to this question, but rather a range of reasonable answers. Keep in mind that, since we know that there is 1 intelligent communicating civilization in the universe (us!), N cannot be <1, which means no individual factor can be zero, so your values can be very small, but it they end up multiplying together to equal something less than 1, you know you've been overly pessimistic and should revise one or more of them.

Once you've done all of your estimates from the clues, fill out the table below. Each answer should have units.

Factor	Estimate
n_s	
T *remember to divide by this!*	
f_p	
n_h	
f_l	
f_i	
f_c	
L	
Final Estimate	

Followup questions:

1) Which of the factors were the hardest to estimate and why?
2) What did you find most surprising or interesting about this calculation?
3) Brainstorm 2-3 additional factors that are not included in this calculation but might make a difference to the final outcome, and explain in a sentence or two each why you think they might matter. Do NOT use the internet – come up with these on your own.
4) Compare your answers to both the Drake Equation and question (3) above with another group. Don't redo any of your answers, but explain:

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a. The differences between their estimates and yours. On what factors did your estimates differ significantly and by how much?
b. What did they think of for (3) that you didn't and do you think their additional factors are important?