

The Drake Equation

We have learned that:

- Organic molecules are common
- Life arose fairly quickly on Earth, probably several times
- Life can thrive in extreme environments
- Planets are not rare
- There are lots of stars in our galaxy

This suggests that there may be (other) intelligent life in our galaxy.

How can we discuss this possibility in a rational way? What things must we consider?

The Drake equation addresses (not answers!) the question:

How many civilizations exist in our galaxy with whom we could communicate?

One revised form of the Drake equation, based on Goldsmith and Owen:

$$N = N_* f_p N_p f_l f_i L / L_g$$

Where N is the number of civilizations in the galaxy that we can communicate with.

Goldsmith & Owen's Drake Equation Evaluation:

N_* = # stars = 300 billion

f_p = fraction of ok stars w/ planets = F,G,K stars = 1/200

N_p = # suitable planets per star = ? ~ 1

f_l = fraction w/ life ~ ? ~ 1/2

f_i = intelligence and communication = ? ~ 1/3

L = lifetime of a civilization = ??? = L

L_g = lifetime of galaxy = 10 billion years

and so $N = L / 40$

Following Goldsmith & Owen, if the lifetime L of a civilization that wants to communicate is:

L = 100 years, then N = only 2 or 3 civilizations in our entire galaxy

L = 1000 years, N = 25

L = 150 million years, N = 3.75 million civilizations in our Milky Way

Astr310's Drake Equation Evaluation:

$N_* = \# \text{ stars} = 300 \text{ billion}$

$f_p = \text{ok stars w/ planets} = \text{F,G,K star} = 1/200$

$N_p = \# \text{ suitable planets per star} = ?$

$f_l = \text{fraction w/ life} = ?$

$f_i = \text{intelligence and communication} = ?$

$L = \text{lifetime of a civilization} = ?$

$L_g = \text{lifetime of galaxy} = 10 \text{ billion years}$

$N \sim 1/6 (\quad) = \quad \text{civilizations}$

Optimist's Drake Equation Evaluation:

$N_* = \# \text{ stars} = 400 \text{ billion}$

$f_p = \text{ok stars w/ planets} = \text{F,G,K star} = 1$

$N_p = \# \text{ suitable planets per star} = 3$

$f_l = \text{fraction w/ life} \sim 1$

$f_i = \text{intelligence and communication} = 1$

$L = \text{lifetime of a civilization} = ??? = L$

$L_g = \text{lifetime of galaxy} = 10 \text{ billion years}$

$N = 120 L !!$

Pessimist's Drake Equation Evaluation:

$N_* = \# \text{ stars} = 200 \text{ billion}$

$f_p = \text{ok stars w/ planets} = \text{F,G,K star} = 1/1000$

$N_p = \# \text{ suitable planets per star} = 1/10$

$f_l = \text{fraction w/ life} \sim 1/200$

$f_i = \text{intelligence and communication} = 1/100,000$

$L = \text{lifetime of a civilization} = ??? = L$

$L_g = \text{lifetime of galaxy} = 10 \text{ billion years}$

$N = L / 10 \text{ billion} !!$

Closing thoughts on the "Drake Equation":

- 1) does not tell us how many civilizations there are, but it is a starting point for discussion
- 2) estimates range from zero to hundreds of millions *in our galaxy*
- 3) this applies to only one galaxy of the *billions* that exists.