

## Evaluating your Drake Equation

### Basic Ideas

- Number of Civilizations in our Galaxy
  - Product of rate of emergence and  $L$ 
    - Running product gives rate for each step
    - Until  $L$ , we have rates
    - Through  $f_c$ , we get “communicable” civilizations
  - Multiplying by  $L$  gives the number ( $N$ )
    - Assumes “steady state” between birth and death of civilizations

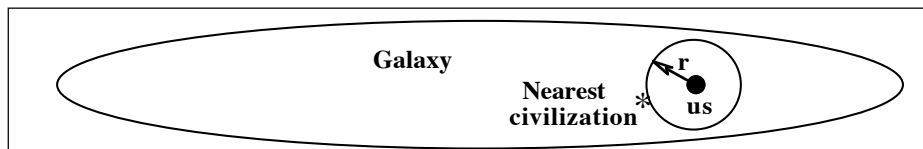
## Drake Equation:

$$N = R_* f_p n_e f_l f_c L$$

N	=	number of communicable civilizations in our galaxy
$R_*$	=	Rate at which stars form
$f_p$	=	Fraction of stars which have planetary systems
$n_e$	=	Number of planets, per planetary system, which are suitable for life
$f_l$	=	Fraction of life bearing planets where intelligence develops
$f_c$	=	Fraction of planets with intelligent life which develop a technological phase during which there is a capacity for and interest in interstellar communication
L	=	Average of lifetime of communicable civilizations
r	=	Average distance to nearest civilization

## Distance to Nearest Neighbor

1. Assume civilizations spread uniformly but randomly through galaxy

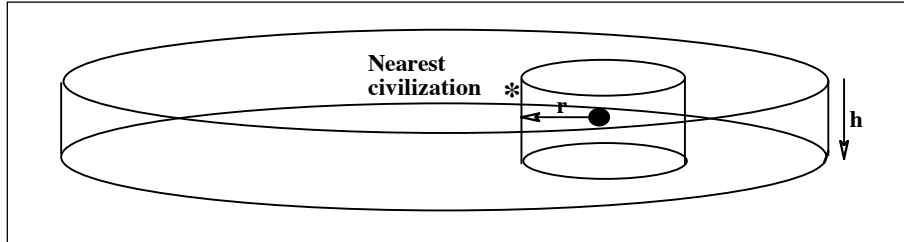


r = radius of imaginary sphere centered on us that touches nearest civilization

$$\text{search vol} \propto r^3$$

$$\Rightarrow r = \frac{10^4 \text{ ly}}{N^{1/3}}$$

## Distance to Nearest Neighbor



If  $N < 8000$ ,  $r$  from previous formula is  $500 \text{ ly}$   
 About equal to thickness of Galaxy

Use cylinder for search vol  $\propto r^2 h$

$$\text{so } r = \frac{5 \times 10^4 \text{ ly}}{N^{1/2}}$$

## Happy Feller



	R	$f_p$	$n_e$	$f_z$	$f_i$	$f_c$	L	N	r
Estimate	50	1	1	1	1	1	$5 \times 10^9$	$2.5 \times 10^{11}$	$1.6 \text{ ly}$
Birthrate	50	50	50	50	50	50			

↑  
2.5 out of 4 stars

$$\text{If } N > 8000, \quad r = \frac{10^4 \text{ light years}}{N^{1/3}}$$

$$\text{If } N < 8000, \quad r = \frac{5 \times 10^4 \text{ light years}}{N^{1/2}}$$

# Angela Angst



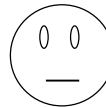
	R	$f_p$	$n_e$	$f_l$	$f_i$	$f_c$	L	N	r
Estimate	5	0.1	0.1	0.01	0.01	0.01	100	$5 \times 10^{-6}$	---
Birthrate	5	0.5	0.05	$5 \times 10^{-4}$	$5 \times 10^{-6}$	$5 \times 10^{-8}$			

Never two civilizations  
at same time

If  $N > 8000$ ,  $r = \frac{10^4 \text{ light years}}{N^{1/3}}$

If  $N < 8000$ ,  $r = \frac{5 \times 10^4 \text{ light years}}{N^{1/2}}$

# Mr. Average Guy



	R	$f_p$	$n_e$	$f_l$	$f_i$	$f_c$	L	N	r
Estimate	10	0.5	0.89	0.5	0.7	0.6	$1 \times 10^6$	$9.4 \times 10^5$	100
Birthrate	10	5	4.45	2.23	1.56	0.94			

↑  
1 out of  
 $4 \times 10^5$  stars

→  $10 \times 10^5 = 10^6$

If  $N > 8000$ ,  $r = \frac{10^4 \text{ light years}}{N^{1/3}}$

If  $N < 8000$ ,  $r = \frac{5 \times 10^4 \text{ light years}}{N^{1/2}}$

## Evaluating YOUR Drake Equation

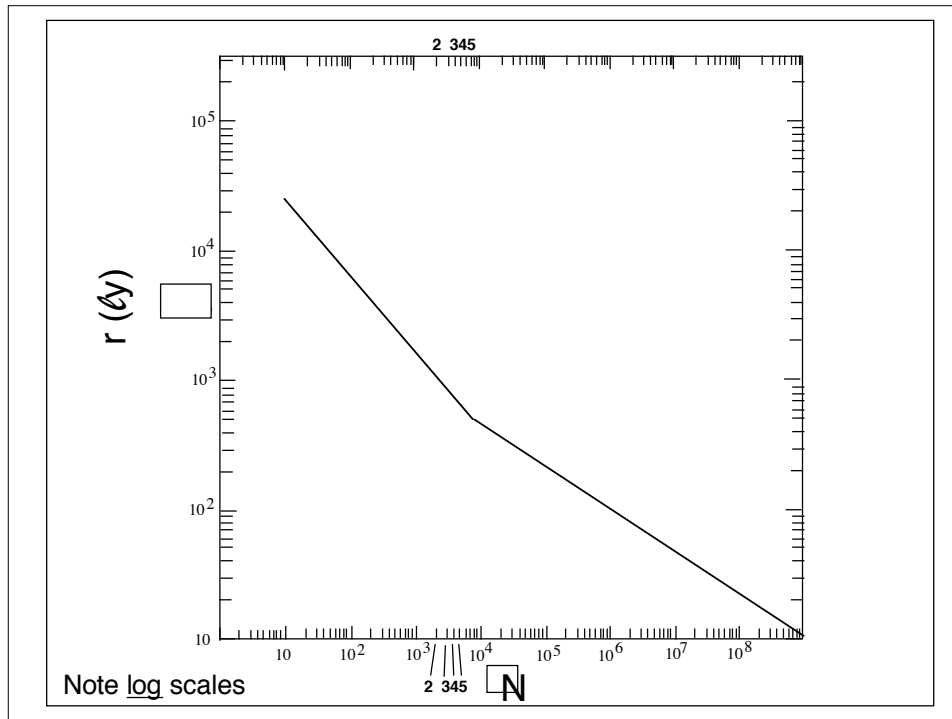
- Almost no answers are wrong
  - It must be possible for us to exist
  - N must be no greater than the number of stars in the Galaxy
    - May imply limit on L
- Ways to evaluate:
  - Plug into equations
  - Use calculator on web
  - Ask us for help

## Your Drake Equation

	R	$f_p$	$n_e$	$f_z$	$f_i$	$f_c$	L	N	r
Estimate									
Birthrate									

$$\text{If } N > 8000, \quad r = \frac{10^4 \text{ light years}}{N^{1/3}}$$

$$\text{If } N < 8000, \quad r = \frac{5 \times 10^4 \text{ light years}}{N^{1/2}}$$



### Points to bear in mind

- $r$  is based on assuming spread uniformly
  - Could be less in closer to center of MW
- $r$  is based on averages
  - Could be closer but unlikely
- $r$  is less uncertain than  $N$
- Since signals travel at  $c$ , time = distance in ly
- If  $L < 2r$ , no two way messages