# 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

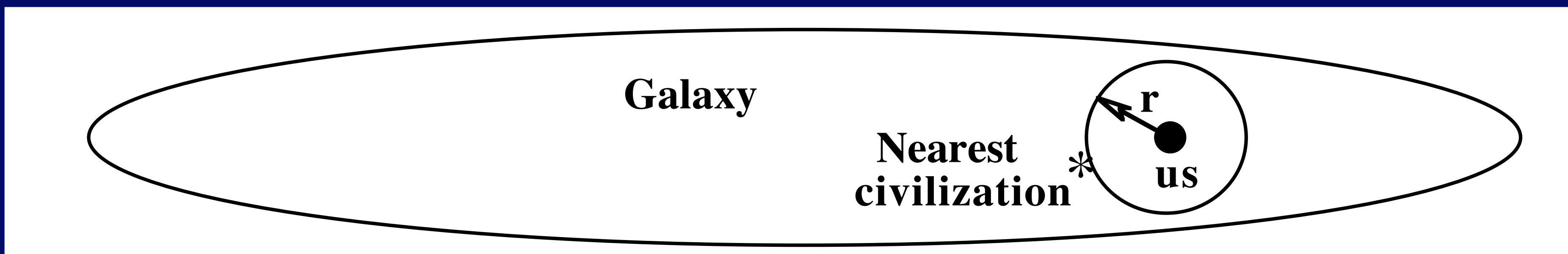
# Drake Equation:

$$N = R_* f_p n_e f_\ell f_i f_c L$$

| | | |
|---|---|---|
| $N$ | = | 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, wh |
| $f_\ell$ | = | Fraction of suitable planets where life arises |
| $f_i$ | = | 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 lifetime of communicable civilizations |
| $r$ | = | Average distance to nearest civilization |

# Distance to Nearest Neighbor

1. Assume civilizations spread uniformly but randomly through galaxy

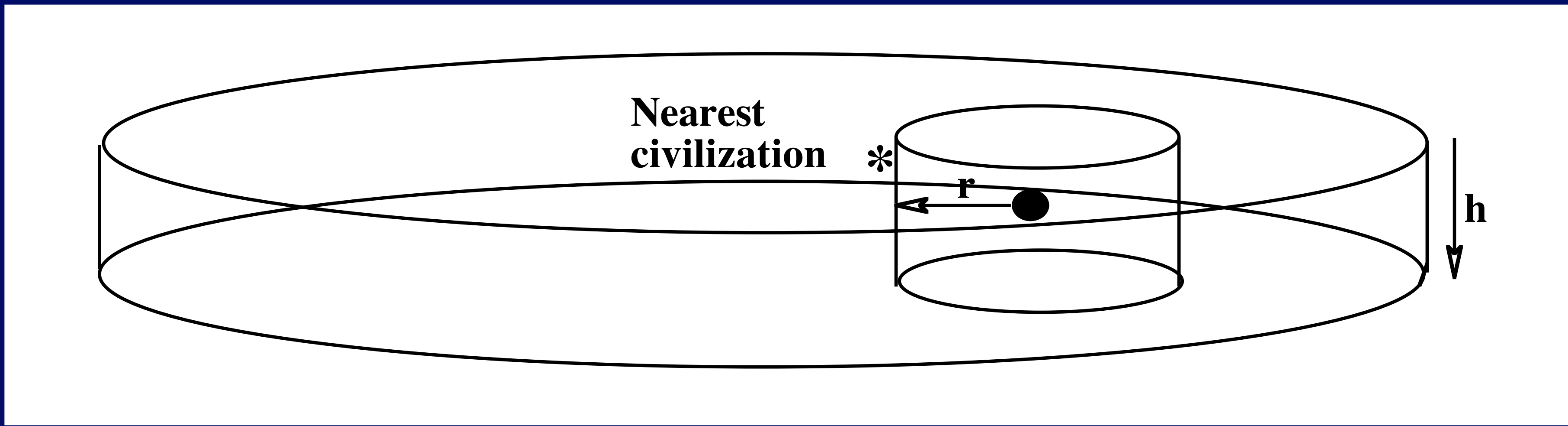



r = radius of imaginary sphere centered on us that touches nearest civilizaztion

search vol $\propto r^3$

$$\Rightarrow r = \frac{10^4\ \ell y}{N^{1/3}}$$

# Distance to Nearest Neighbor




If $N < 8000$, $r$ from previous formula is 500 $\ell y$

About equal to thickness of Galaxy

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

so $r = \dfrac{5 \times 10^4 \ \ell y}{N^{1/2}}$

# Happy Feller

| | R | $f_p$ | $n_e$ | $f_\ell$ | $f_i$ | $f_c$ | L | N | r |
|---|---|---|---|---|---|---|---|---|---|
| Estimate | 50 | 1 | 1 | 1 | 1 | 1 | $5 \times 10^9$ | $2.5 \times 10^{11}$ | $1.6\ \ell y$ |
| Birthrate | 50 | 50 | 50 | 50 | 50 | 50 | | | |

2.5 out of 4 stars

If $N > 8000$,

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

If $N < 8000$,

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

# Angela Angst

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

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

| | $R$ | $f_p$ | $n_e$ | $f_\ell$ | $f_i$ | $f_c$ | $L$ | $N$ | $r$ |
|---|---|---|---|---|---|---|---|---|---|
| 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

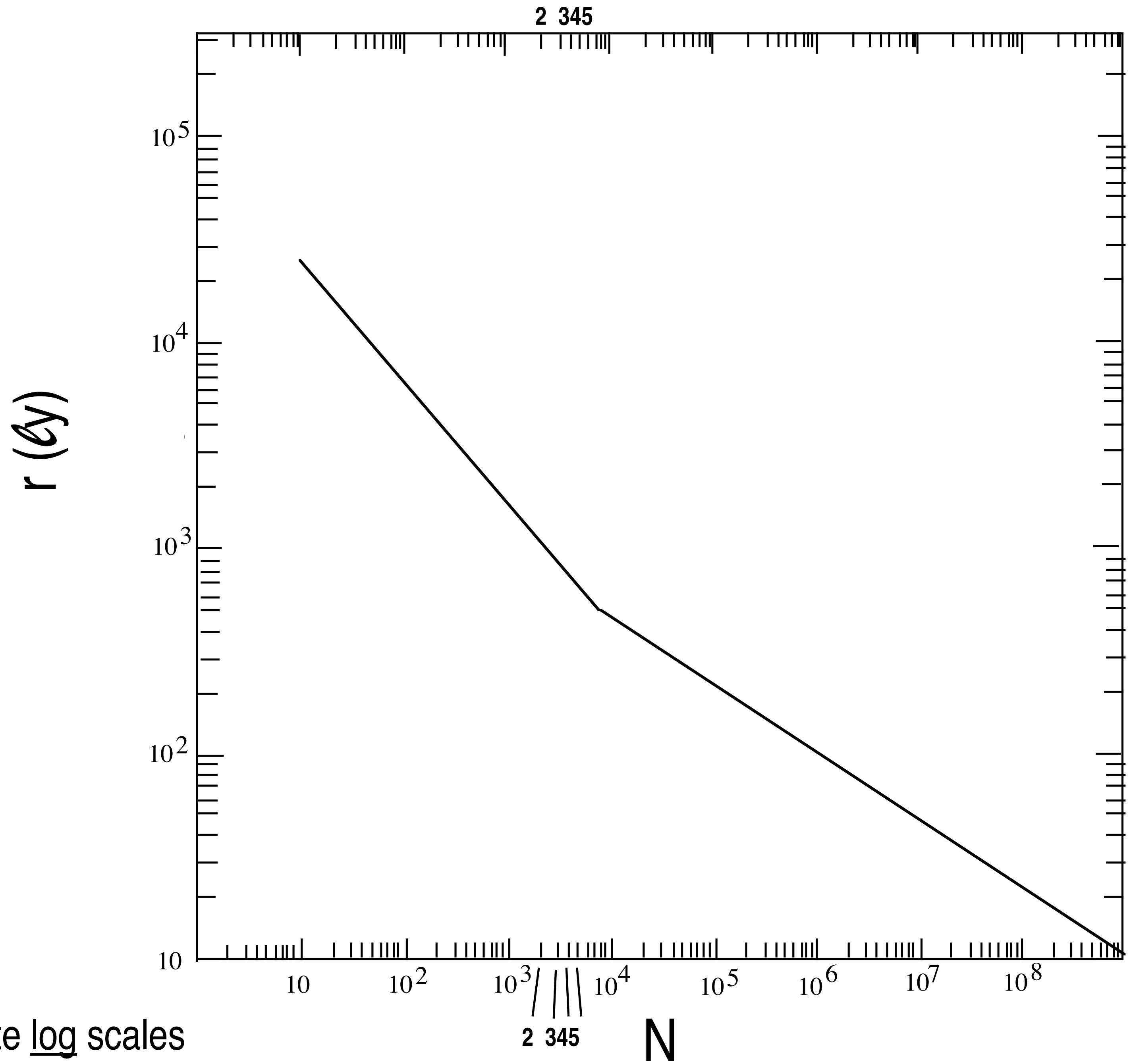
- Almost no answers are wrong
  - It must be possible for us to exist
  - N must be no greater than the number of stars in the Galaxy
    - May imply limit on L
- Ways to evaluate:
  - Plug into equations
  - Use calculator on web
    - http://www.as.utexas.edu/astronomy/education/drake/drake.html
  - Ask us for help

# Your Drake Equation

| | $R$ | $f_p$ | $n_e$ | $f_\ell$ | $f_i$ | $f_c$ | $L$ | $N$ | $r$ |
|---|---|---|---|---|---|---|---|---|---|
| Estimate | | | | | | | | | |
| Birthrate | | | | | | | | | |

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

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




Note log scales

# Points to bear in mind

- r is based on assuming spread uniformly
  - Could be less if 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