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:

\[ N = R \ast f_p n_e f_\ell f_i f_c L \]

- **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, which are suitable for life
- **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
Treat the Galaxy as a Thin Cylinder
Distance to Nearest Neighbor

1. Assume civilizations spread uniformly but randomly through galaxy

\[ r = \text{radius of imaginary sphere centered on us that touches nearest civilization} \]

search vol \( \propto r^3 \)

\[ \Rightarrow r = \frac{10^4 \ \ell y}{N^{1/3}} \]
If the Search Sphere gets too big…

If $N < 8000$, $r$ from previous formula is $500 \, \text{ly}$

About equal to thickness of Galaxy

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

so $r = \frac{5 \times 10^4 \, \text{ly}}{N^{1/2}}$
<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>f_p</th>
<th>n_e</th>
<th>f_ϵ</th>
<th>f_i</th>
<th>f_c</th>
<th>L</th>
<th>N</th>
<th>r</th>
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<tbody>
<tr>
<td>Estimate</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5 × 10^9</td>
<td>1 × 10^{11}</td>
<td>2.2 ly</td>
</tr>
<tr>
<td>Birthrate</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
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62.5% of stars

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

If \( N < 8000 \),
\[
r = \frac{5 \times 10^4 \text{ light years}}{N^{1/2}}
\]
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<tr>
<th></th>
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<th>$f_\xi$</th>
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<tr>
<td><strong>Estimate</strong></td>
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<td>0.1</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>100</td>
<td>$5 \times 10^{-6}$</td>
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<tr>
<td><strong>Birthrate</strong></td>
<td>5</td>
<td>0.5</td>
<td>0.05</td>
<td>$5 \times 10^{-4}$</td>
<td>$5 \times 10^{-6}$</td>
<td>$5 \times 10^{-8}$</td>
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**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 (~2000)

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>f_p</th>
<th>n_e</th>
<th>f_ℓ</th>
<th>f_i</th>
<th>f_c</th>
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<tbody>
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<td>10</td>
<td>0.5</td>
<td>0.89</td>
<td>0.5</td>
<td>0.7</td>
<td>0.6</td>
<td>1 × 10^6</td>
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<td>1.56</td>
<td>0.94</td>
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If \( N > 8000 \),
\[
r = \frac{10^4 \text{ light years}}{N^{1/3}}
\]

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

\(~1 \text{ out of } 1.6 \times 10^5 \text{ stars} \)

\(10 \times 10^5 = 10^6\)
Mr. Average Guy (~2014)

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<td>$4.6 \times 10^8$</td>
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<td>1.8</td>
<td>0.72</td>
<td>0.44</td>
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~1 out of 1500 stars

Note: the birthrate is actually lower than earlier class. The longer lifetime makes all the difference!
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](http://www.as.utexas.edu/astronomy/education/drake/drake.html)
  – Ask us for help
Your Drake Equation

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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