The Quest for Extraterrestrial Signals

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Preliminary thoughts

a. How certain are you that other solar systems are common?
b. How certain are you that other Earth-like planets are common?
c. How certain are you that extraterrestrial life is common?
d. How certain are you that extraterrestrial intelligent life is common?
e. How certain are you that it is common for intelligent life to try to communicate its existence to other worlds?
f. How certain are you that intelligent life would colonize?

Extraterrestrial Life Debate – Not New

- Philosophy/Cosmology/World-View inspired:
  - Atomist (Epicurus) – 5th century BC
  - Lucretius – 1st century AD
  - Giordano Bruno (heretic) – 16th century
  - Kepler (Moon) – 16th century
  - Voltaire (Micromegas -- aliens) – 18th century
  - Thomas Paine (Common Sense) – 1776
- Scientists:
  - Sir John Herschel (Moon & Sun) – 19th century
  - Percival Lowell (Mars) – 1894/95
  - Marconi (Detects radio waves from Mars) -- 1920

Opinions on The Search for Extraterrestrial Intelligence

a) It is not science research
b) It is science research but not very worthwhile
c) It is worthwhile
d) It is an imperative area of research

Cost and risk versus possible payoff

Searching for Extraterrestrial Signals is a Lot Like Searching for Unicorns

- If one can estimate there's a high likelihood there's one Unicorn per square mile, then the search would have low costs
- If one can estimate Unicorns are extremely rare, no more than one per 10,000 square miles, what must one do to definitively determine that not even one Unicorns exists?

The Drake Equation

$$N = R^{*} \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

- *N* = the number of civilizations in our galaxy for which communication might be possible
- R^* = The rate of formation of stars suitable for the development of intelligent life.
- f_p = The fraction of those stars with planetary systems
- n_e = The number of planets, per solar system, with an environment suitable for life.
- f_l = The fraction of suitable planets on which life actually appears.
- f_i = The fraction of life bearing planets on which intelligent life emerges.
- f_c = The fraction of civilizations that develop a technology that releases detectable signs of their existence into space
- *L* = The length of time such civilizations release detectable signals into space.

Quoted from: http://www.seti.org/drakeequation

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- *N* = the number of civilizations in our galaxy for which communication might be possible = 28,000,000 – mean separation 30 lyrs (about 10 pc)
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We have an actual, singular amazing observation. A critical piece of scientific data.

There has never been a detection of an ET

- Fermi Paradox
  - Some civilizations will develop interstellar travel.
  - the Milky Way galaxy would be covered in about a million years even with slow interstellar speeds
  - The Milky Way is 10 billion years old.
- Some term in the Drake Equation acts as a barrier to the formation of intelligent life
- And/or L is relatively short

Rare Earth Hypothesis (Pessimistic)

$$N = N^* \cdot n_e \cdot f_g \cdot f_p \cdot f_{pm} \cdot f_i \cdot f_c \cdot f_l \cdot f_m \cdot f_j \cdot f_{me}$$

- N*=Number of stars in the Milky Way: 10^{11} – 5x 10^{11}
- n_e=Number of planets in the habitable zone
- f_g = fraction in the galactic habitable zone
- f_p = fraction of stars with planets
- f_{pm} = fraction of planets that are rocky
- f_i = fraction of planets that can develop microbial life
- f_c = fraction of planets that develop complex life
- f_l = fraction of a planet's lifetime that can support life
- f_m = fraction of planets with a large moon
- f_p = fraction of planetary systems with a Jovian moon
- f_{me} = fraction of planets with a low number of extinction events

Rare Earth Hypothesis

- Other considerations
  - Right kind of galaxy
  - Right kind of star
  - Stable orbit
  - Something must stop the typical planetary migrations that would destroy rocky planets in the habitable zone
  - Fast rotating planet – requires a collision with another planet-sized object
  - Magnetic field
  - Low but not zero intrinsic nuclear radiation
  - Plate tectonics and a tilted axis to promote evolution

How did life get started? Complex life? Intelligent life?

- Chemist/Biologist have some ideas on how to get the chemistry of life started
  - Known chemistry reaction rates cannot produce the complexity of life in less then 1 million years
- Panspermia
- Comets, etc. seeded the Earth with the complex molecules known to form and exist in interstellar space which jump started the chemistry.
  - And then there’s Mars.
- Chemist/Biologist also have some ideas on why it is inevitable that eventually complex life forms would develop.

What are SETI searches like?

- Optical – encoded messages on collimated light beams
- Infrared – the signature of Dyson spheres (Soviet Union/Russians)
- Radio (US)
  - 1-5 GHz
  - High time resolution
  - High frequency resolution
  - Pointed observations toward particular stars
  - Commensal/Piggy-back experiments

But, if you don’t do the experiment, you won’t know the answer.

And, what would be the consequences if the answer turns out to be: yes??

What protocols should scientist follow if a detection is made?

Final thoughts

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