Is there extra-terrestrial Life?

Is there Intelligent extra-terrestrial Life?
Life formed on Earth relatively soon after the planet’s formation 4.5 billion years ago.
For 75% of the Earth’s history, only algae and single-celled life forms existed.

By 250 million years (5%) before the present, dinosaurs and early mammals had evolved.

Hominids, our distant ancestors, developed 5.5 million years ago (0.1%)
Homo Sapiens evolved only 500,000 years ago! (0.01%)

Living organisms like those on the Earth may exist on planets going around stars other than the Sun because
a) we have detected comets in other stellar systems.
b) life here may have been 'planted' by other civilizations.
c) lifeforms on Earth may have disseminated elsewhere.
d) the laws of physics and chemistry are universal.
e) some stars emit radio signals.
Life tends to draw on the substances that are most plentiful: Carbon, Nitrogen, Oxygen and Hydrogen.

Amino acids are organic molecules containing these substances.

Amino acids form proteins, which provide structure and energy to cells.

All life contains DNA – this instruction packet contains all the information needed to build an organism.

The Search for Life on Mars

It appears that Mars at some point in its history was very much wetter and warmer than it is today.

Scientists have been looking for life there.

The Viking landers (1970’s) tested for the presence of microbes, but returned inconclusive results.

We are still looking!
Life as we know it on Earth could only form in a "habitable zone", which is the range
   a) in the galaxy where there is enough oxygen.
   b) of distances from a star where most water will be liquid.
   c) of latitudes that stay warm during an ice age.
   d) of time when there is no longer bombardment by comets and asteroids.

Fossils of Ancient Martian Life?
How would we estimate the chances of Intelligent life being found elsewhere in the universe? How would we search for them?

**SETI.**

- SETI: Search for *Extra-Terrestrial Intelligence*
- Listens for electromagnetic evidence of intelligence elsewhere in the universe
- To date, evidence has been sparse.
Drake Equation

Estimates the number of observable civilizations in the Galaxy

\[ N = N^* \cdot f_p \cdot N_e \cdot f_l \cdot f_i \cdot f_c \cdot L / T_g \]

- \( N \) is the number of civilizations in our galaxy with which we might hope to be able to communicate;
- \( N^* \) is the number of stars in our Galaxy
- \( f_p \) is the fraction of those stars that have planets
- \( n_e \) is the average number of planets that can potentially support life per star that has planets
- \( f_l \) is the fraction of the above that actually go on to develop life at some point
- \( f_i \) is the fraction of the above that actually go on to develop intelligent life
- \( f_c \) is the fraction of civilizations that develop a technology that releases detectable signs of their existence into space
- \( L \) is the length of time such civilizations release detectable signals into space.
- \( T_g \) is the age of the galaxy.

Historically:
- \( R^* = 10 / \text{year} \) (10 stars formed per year, on the average over the life of the galaxy)
- \( f_p = 0.5 \) (half of all stars formed will have planets)
- \( n_e = 2 \) (2 planets per star will be able to develop life)
- \( f_l = 1 \) (100% of the planets will develop life)
- \( f_i = 0.01 \) (1% of which will be intelligent life)
- \( f_c = 0.01 \) (1% of which will be able to communicate)
- \( L = 10,000 \) years (which will last 10,000 years)

Drake's values give

\[ N = 10 \times 0.5 \times 2 \times 1 \times 0.01 \times 0.01 \times 10,000 = 10. \]
Current Best estimates:
• $fp$ = the fraction of those stars which have planets
  Estimated by Drake as 0.5. It is now known from modern planet searches that at least 10% of sunlike stars have planets, and the true proportion may be much higher, since only planets gas-giant size and larger can be detected with current technology.[3]
• $ne$ = Estimated by Drake as 2. The same paper by Marcy, notes that most of the observed planets have very eccentric orbits, or orbit very close to the sun where the temperature is too high for earth-like life.
• $fl$ = In 2002, Charles H. Lineweaver and Tamara M. Davis estimated $fl$ as $> 0.13$ on planets that have existed for at least one billion years using a statistical argument based on the length of time life took to evolve on Earth.
• $fi$ = Some estimate that solar systems in galactic orbits with radiation exposure as low as Earth's solar system may be more than 100,000 times rarer, however, giving a value of $fi = 1 \times 10^{-7}$.
• $fc = 0.01$
• $L = 10,000$ for $L$ is still the most popular estimate

• $R^* = 6/\text{year}$, $fp = 0.5$, $ne = 2$, $fl = 0.33$, $fi = 0.01$, $fc = 0.01$, and $L = 10000$ years
• $N = 6 \times 0.5 \times 2 \times 0.33 \times 0.01 \times 0.01 \times 10000 = 2$