# Lecture 41: Science Fact or Science Fiction? Intelligent Life in the Universe

# Four Opinions:

1. It is highly likely that intelligent life has arisen elsewhere in the Universe.

2. There is no evidence of extraterrestrial visits to the Earth, now or in the past.

3. Lack of visits may be explained by the extreme difficulty of interstellar travel.

4. If we do make contact, it will be by receiving radio signals.

# Basic Requirements for Life

Energy

Warmth to permit liquid water (liquid methane?)

Energy to fuel chemical reactions

Complex chemistry

Elements heavier than H and He

Carbon as building blocks for complex molecules

Protection from harmful UV light

Mutations inhibit emergence of complex life Ozone layer, underwater, or underground

# Extreme Life on Earth

Dark Life

Bacteria that thrive many kilometers beneath the Earth or deep in polar ice.

Hot Life

Microbes surviving in boiling geysers, pools and deep ocean thermal vents

On the Moon:

Strep bacteria survived 3 years on the lunar surface!

# Life in the Solar System?

Mars

May have liquid water and a thicker atmosphere in the past Europa

Liquid water ocean warmed by tides Protected by outer shell of ice

Titan

Methane chemistry Complex molecules present

Each may satisfy the basic requirements for life to develop

# What do we mean by "Intelligent"

This usually means:

A highly advanced technological civilization Capable of communicating across interstellar distances Capable of interstellar travel by spacecraft Interested in finding and communicating with other intelligences.

In other words: life like us.

# Do we qualify as "Intelligent"?

Just barely:

Only had radio communications technology for ~100 years Only had limited (short-duration) manned spaceflight for ~40 years. Only sent robotic spacecraft to the edges of our Solar System in the last decade

May or may not yet have sufficiently sensitive radio reception technology

#### Sheer Weight of Numbers

The primary reason I think life must have arisen elsewhere is the sheer number of stars in the visible Universe:

~200 billion galaxies in the visible Universe

~100 billion stars per galaxy

Total of  $\sim 2x10^{22}$  (20 billion trillion) stars

Even one chance in a trillion would yield more than 20 billion possible sites for life.

## Planetary Requirements for Life

Long-lived, stable star Good: F, G, &K stars: last > 3 Gyr Bad: O, B & A stars: short-lived, high UV output (damaging to organic molecules) Bad: M stars: small & dim, powerful flaring Stable orbital environment Excludes more binary star systems Metals=chemically evolved environment Need metals to make rocky planets Need carbon for complex molecules

# The Drake Equation

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

*N*=number of advanced civilizations in the Galaxy  $R_*$ =rate at which Sun-like stars form  $f_p$ =fraction of stars with planetary systems  $n_e$ =number of Earth-like planets per system  $f_l$ =fraction of Earth-like planets with life  $f_i$ =fraction where intelligent life has evolved  $f_c$ =fraction with communication technology L=lifetime of an advanced civilization

# Measurement and Conjecture

Only the first 3 terms of the Drake Equation can be measured by astronomers:

Star formation rate:  $R_* \sim 1$  per year (F, G, & K stars) Fraction of Stars with Planets  $f_p \sim 0.1$ -0.2 from recent planet searches  $n_e$  number of Earth-like planets per system may be measurable in the next few years The rest are purely conjectural

## Shameless Optimism

One very optimistic view:

 $n_e=0.1$  (1 in 10 solar systems have earths)  $f_i=1$  (if earth-like, life is inevitable)  $f_i=$  (if life, intelligence is inevitable)  $f_c=$  (if intelligence, technology is inevitable) L=100 years (we made it this far....so far....)

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

$$N = 1 \times 0.2 \times 0.1 \times 1 \times 1 \times 1 \times 100$$
  

$$N = 2$$

# Extraterrestrial Visitations? No.

"Extraordinary claims require extraordinary proof" No extraordinary proof has been offered:

Fuzzy photographs Anecdotal accounts of visits & abductions Claims of government conspiracies These do not count

There are unexplained sightings, but failure to explain them does not justify a leap to a truly wild explanations.

#### Where are they?

The extreme difficulty of interstellar travel is a plausible explanation of a lack of visits.

The distances between stars are enormous:

Need very large amounts of time or

Extremely large amounts of energy

The fastest spacecraft: Voyager 1&2

Outward bound at 15 km/sec (0.005% c)

Need 80,000 years to reach the nearest stars

#### **Relativistic Starships**

Accelerate a starship to near-light speeds Need 0.1c to reach nearest star in 50 years Energy costs are enormous Amount of fuel increases exponentially with the acceleration time (use more fuel at first) 50% max efficiency for matter/anti-matter fuel But the production efficiency is extremely low

Possible given a sufficiently advanced technology?

Talk is Cheap! (and travels at the speed of light)

If you really want to bridge interstellar distances, use light to send messages. Messages travel at the speed of light

Very low energy cost per message

What wavelengths to use?

Microwaves 1000-10000 MHz is a region of relatively low cosmic background "noise"

Lasers at visible to IR wavelengths: very few natural lasers in the sky to cause confusion

#### Earth is already on-the-air

We have been inadvertently beaming radio signals into space for the last 80 years:

Radio broadcasts from the 1920s onward Television broadcasts from the 1950s onward We could detect these with current technology

Episodes of "I Love Lucy" will have already reached most solar neighborhood stars (~40 light years)... is this a good thing?

#### Increasing radio silence

Earth's radio brightness has been *decreasing* Introduction & spread of cable TV Increased use of "directed" communication (e.g., fiber optics, beamed satellite, etc.)

Sufficiently advanced civilizations may emit less "waste radio" & become radio quiet:

If a civilization wants to be found, it may have to deliberately broadcast its presence.

The Search...

SETI:

Search for Extra-Terrestrial Intelligence A relatively inexpensive search strategy to look for radio signals from extraterrestrial civilizations.

Phoenix project of the SETI Institute Optical & Microwave SETI at Harvard Various smaller projects

What are we looking for?

Signals that appear "artificial"

Very narrow "bandwidth" (<300 Hz, the narrowest natural maser sources) Pulsed signals (common way to encode information) Highly polarized signals (another encoding scheme) Very little frequency "drift"

So far, no detections...

Pioneer 10 detected. Nice to know we can detect our own artificial signals from deep space.

What if we detect something?