Plan of Lecture

Life in the Universe

What questions do you have about life in the universe?

Life and Astrobiology

Our planet is the only one we know to have life.

Why?

What is life?

What is required for life?

Detection of life elsewhere?

A fundamental question is: are we alone?

To estimate the likelihood for life elsewhere, we need to think of how it might arise.

Very speculative; with only one example, we can easily go wrong!

The Nature of Life

Definitions of life can be a bit foggy.

Self-replicating.

“Eats”, grows.

At boundaries, there are odd exceptions.

Is a virus alive?

Is a snowflake alive?

More generally, extraction and use of energy, plus some form of reproduction, could be life.

On Earth, all forms of life are carbon-based.

Forms long, complex chains.

Can store, extract energy.

Silicon is similar to carbon, but no life on Earth is based on silicon.

Chemical bonds are weaker.

Locations of Life on Earth

Focus on things that are definitely alive.

Bacteria and larger.

Where does life occur on Earth?

On land.

In water.

Near volcanic vents.

In rocks.

In short, practically everywhere we can imagine and more.

In addition, life appeared on Earth at least 3.5 billion years ago.

Essentially as soon as it could!

Life is hardy, and can exist in diverse environments.

Precursors to Life?

Before tackling the problem of life, let's think about some of its precursors.

We are made up of complex organic molecules.

The big one carrying our genetic code is DNA.

Made up of amino acids.

Can these form in some primordial soup?

Yes! Even better, amino acids have been detected in space(!).

The building blocks may be common. But what about life itself?

What is Necessary for Life?

Focus on our type of life: carbon-based.

Liquid water seems important.

Good solvent properties.

Place for molecules to combine.

So, can't be too hot (boiling) or too cold (freezing all the time).

Also, life seemed to take 1 billion years to appear here.

Another 3 billion for complex life.

What are the astronomical requirements?

Habitable zone (liquid water).

Star must be long-lived.

Number of Inhabited Worlds

How many inhabited worlds are in our galaxy?

One way to estimate: break down into factors. Drake's equation.

$$N_c = N^* \cdot f_p \cdot n_{\mathrm{LZ}} \cdot f_L \cdot f_I \cdot F_S$$

where

N^*=# of stars in galaxy.

f_p= fraction of stars with planets.

n_{LZ}=average # planets in life zone.

f_L=probability that life will originate.

f_I=fraction of those with intelligence.

F_S=fraction of star's life in which the life form is communicative.

Most factors are unknown!

Extraterrestrial Planets

One factor of the Drake equation is being determined.

f_p, fraction of stars with planets.

More than 120 planets known!

Found from Doppler shifts of parent star.

Mostly limited to big planets.

Smaller ones seen around pulsar.

About 5% of nearby stars have big planets.

Unknown # of smaller planets.

How to find smaller planets? Imaging?

Space Interferometry Mission.

Terrestrial Planet Finder.

Might discover thousands more!

Finding Other Civilizations

How could we find intelligent life? Could we communicate with them?

Spaceships? Inefficient. Long distance, too much energy required for blind search.

EM radiation? Easier to search that way.

Want low noise, low energy.

Best bet: radio?

Recognizing a message may not be easy.

Even if we do, radio waves travel at c.

No two-way communication!

Still, discovery would be spectacular.

Project Phoenix.

SETI@home.

Summary

Life is in every nook and cranny on Earth.

Precursor molecules are common.

Planets around stars are common.

But... no other known life.

If life is common, maybe we'll know of it in our lifetimes!