- Next week is Thanksgiving break
- Leonid meteor shower can be seen the night of the 18th (really the early morning of the 19th). Should see dozens of meteors per hour at the peak – 1:30 am CST.
- The shower is from the Earth's encounter with the 1533 AD dust trail of the comet Tempel-Tuttle.

http://www.space.com/spacewatch/leonids_2003_tips_031107.html

Outline

- Extraterrestrial life
- Drake equation
- Close encounters– UFOs
- Would aliens be good or bad?
  - Are we sure we want to find out?
- How hard is it to define life?
- Extremophiles
- Astrobiology

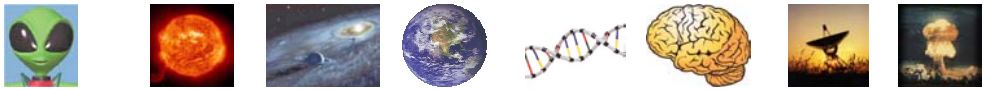
Extraterrestrial Life

What do people who look for extraterrestrial life search for?

What is extraterrestrial life?

Drake Equation

Frank Drake



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

# of advanced civilizations we can contact	Rate of formation of Sun-like stars	Fraction of stars with planets	# of Earthlike planets per system	Fraction on which life arises	Fraction that evolve intelligence	Fraction that communicate	Lifetime of advanced civilizations
10	~ 1 per year	~ 1	~ 0.1 ?	~ 1 ??	~ 1 ???	~ 1 ??!	100 yr ??

Close Encounters

- *First Kind:* Sighting
- *Second Kind:* Physical Evidence
- *Third Kind:* Human-Alien Meeting

- In astronomy, we are really only talking about the first kind and barely– very remote suggestions.

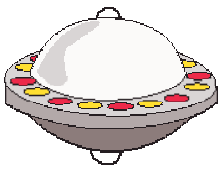
Questions

- How many believe that we have been visited by ETs?

- Are governments hiding it?

Have we been visited by ETs?

"Extraordinary Claims Require Extraordinary Evidence"



What about all the UFO hype?

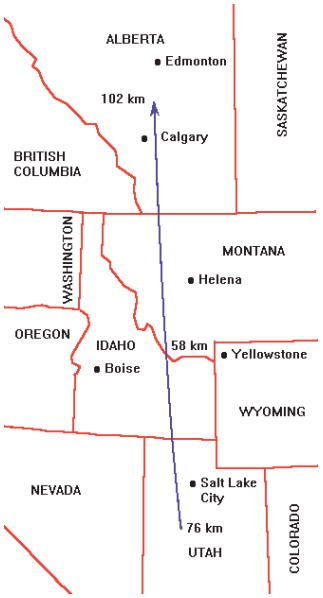
- Sure, UFOs exist. But when they are identified, they are normally weather balloons, 747s, Venus, whatever.
- Even after all you've heard and all you've read in the Enquirer, there is has been no reliable proof of any UFOs being ETs.
- What's the point? What's the gain?
- Remember that the nearest star is around 4 light years. Who pays for the gas money?

An Example: Meteor 1972

http://www.uwgb.edu/dutchs/

Yikes, a Near Miss

- A bus sized object entered atmosphere over Utah and exited over Canada
- Velocity of 15 km/sec
- Missed Earth by 58 km



But…

- Event was completely unexpected
- Crossed relatively sparsely-inhabited region
- Only visible for a *total* of 101 seconds
- Visible for no more than 30 seconds at any one spot
- Nonetheless, we have dozens of clear photographs of this event
- And still we have no comparable images of UFOs

Good or Bad Aliens?

- Humans as Helpers: *E.T.*
- Encounter as Wonder: *Close Encounters of the Third Kind*
- Encounter as Dreary: *Contact*
- Swashbuckling: *Star Wars*
- Satire: *Men In Black*
- Hostile Aliens
  - *Star Trek* and spinoffs (The Borg, the Dominion)
  - *Aliens*
  - *Independence Day*

Perhaps we shouldn't look for Aliens?

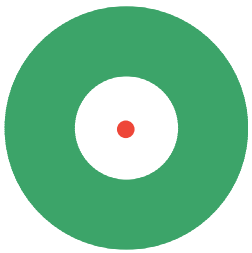
- But we've been broadcasting our presence on Earth for the last 65 years now!
- At the present time, the Earth is brighter in radio than the Sun.
- Is anyone out there watching TV right now?
- Also there have been a few intentional messages…

Life on Earth

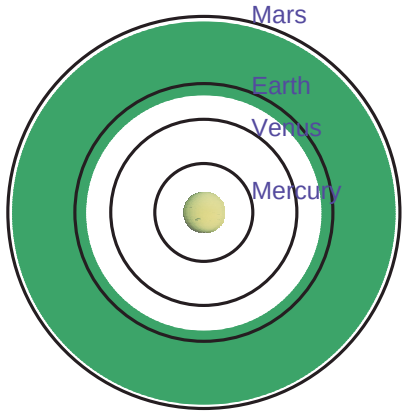
- A miracle?
- An accident?
- More-or-less inevitable given the laws of nature and chemistry with suitable conditions?
- Principle of Mediocrity: There's nothing terribly special about the astronomical, geological, physical and chemical circumstances on Earth; most likely nothing special about biology either

Habitable Zones– Are you in the Zone?

- Long living star
- Planets with stable orbits
- Liquid Water
- Heavy Elements– C, N, O, etc.
- Protection from UV radiation



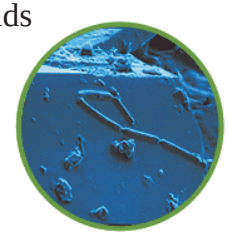
$0.5M_{Sun}$ star



The Sun

Define Life

- Common features:
  - Reacts to environment
  - metabolism (draws energy from environment)
  - Reproduction
  - Evolves?
- Life on Earth
  - Based on complex chemistry of carbon
  - Fundamental building blocks are amino acids
    - Small compounds containing C, O, H, N, S
  - It seems unlikely that life can be based on significantly different chemistry, but…



SETI

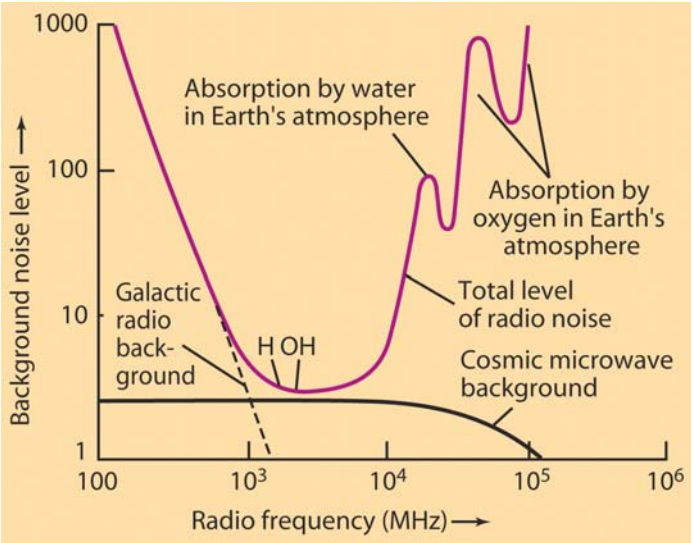
- Communications via radio signal
  - Earth has been broadcasting in RF range for most of this century
  - Earth is brighter than the Sun in radio
  - 18–21 cm wavelength range good for interstellar communication
- SETI search is ongoing
  - SETI
  - **http://www.seti.org**
- If they exist, should we contact them?

ATA

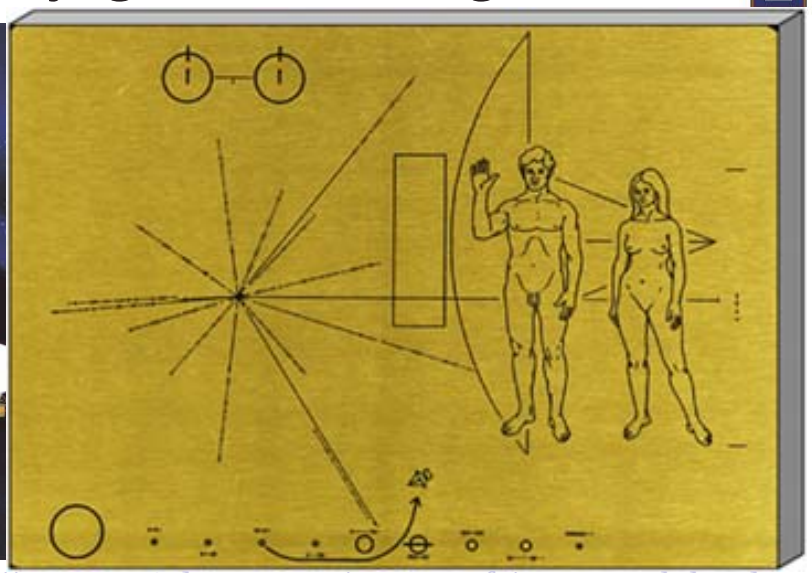
- The Allen Telescope Array– the first 100% dedicated large scale SETI radio telescope.
- Funded by Paul Allen of Microsoft
- Prototype being tested at Hat Creek-- $11M for initial development
- 350 six meter dishes!
- But why do we look for ET in the radio?

The Water Hole

- The best place to listen– in the "quiet" part of the spectrum
- Almost no background radiation around frequencies of water molecule
- Water-based intelligent life might transmit in this frequency band



Voyager– the message is out.



http://voyager.jpl.nasa.gov/spacecraft/sceneearth.html

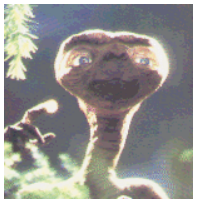
What type of Aliens?

If we took all the biomass of all the animals, and all the biomass of all the viruses, bacteria, protozoa, and fungi– who weighs more?

Around 90% of all biomass on the Earth is in the smallest and simplest lifeforms.

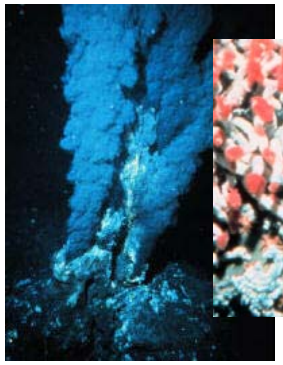
So are we looking for the wrong type of life?

- In your body, there are more microbes cells than you-cells.
- The first life on Earth was a microbe
- They existed for billions of years on Earth– only life for the first 3 billion years
- Microbes can live in more harsh environments– more life in the ground than on top of the ground
- So most likely ET will be microbes too!

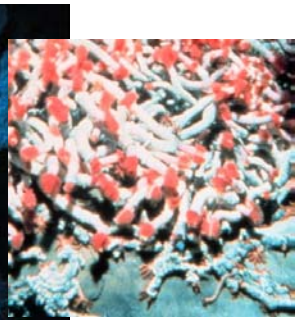


Not your Parent's ET-- Extremophiles

- These are microbes that life in the most extreme places on Earth.
- Temperature extremes
  - boiling or freezing, 100^0C to -1^0C (212F to 30F)
- Chemical extremes
  - vinegar or ammonia (<5 pH or >9 pH)
  - highly salty, up to ten times sea water
- They are exciting because they are the most likely candidate for extraterrestrial life.

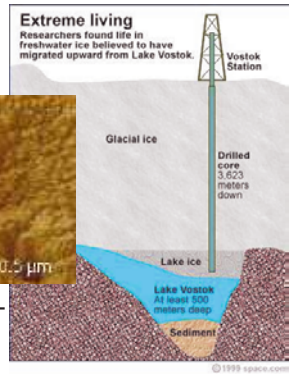


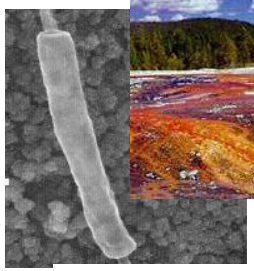
Hydrothermal vent



Tubeworms

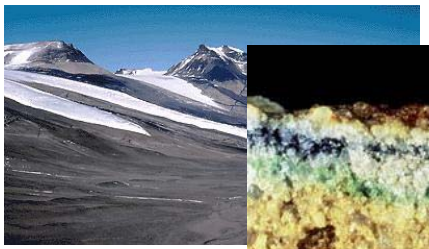
Lake Vostok - Antarctica



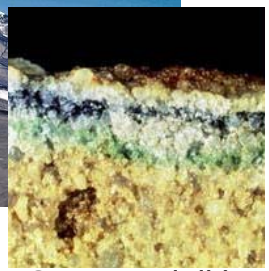


Thermophilic bacteria

Hot springs

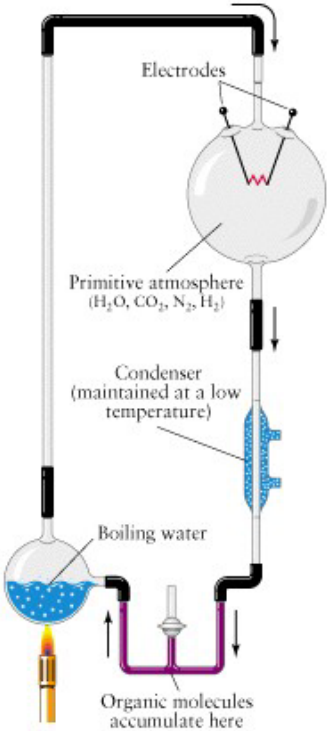


Antarctic dry valley



Cryptoendoliths

- To really search for ET life, we need to better understand life on Earth– Were did it come from?
- Famous experiment in 1956 called the Miller-Urey experiment showed that showed that numerous organic compound necessary for life can be synthesized from gases in a reducing atmosphere (H_2).
- But, now thought that the early Earth's atmosphere was oxidizing (e.g. CO_2, N_2).
- New idea is that as we know of biologically important molecules in interstellar clouds and even comets, perhaps they fell onto the early Earth via comets.
- Or…



This has become even more important in the last few years.

- We have found planets.
- We are building bigger instruments to look for Earth-like planets.
- Can answer the fundamental question: Are we alone?
- New initiative – Astrobiology
  - How life arose on Earth?
  - Conditions necessary for life to arise elsewhere in the Universe?
  - Methods to detect the existence of life elsewhere?