Astronomy 150: Killer Skies
Lecture 38, April 30

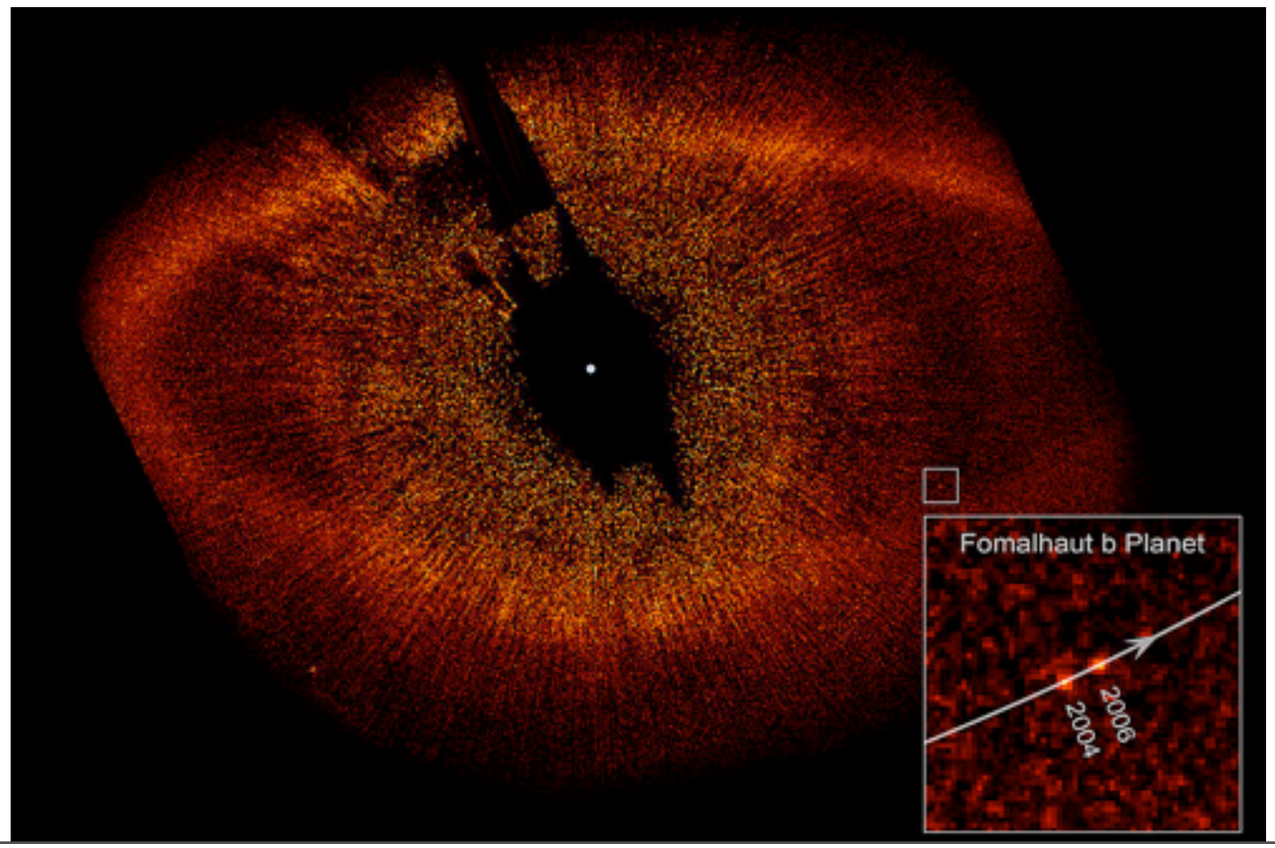
Assignments:

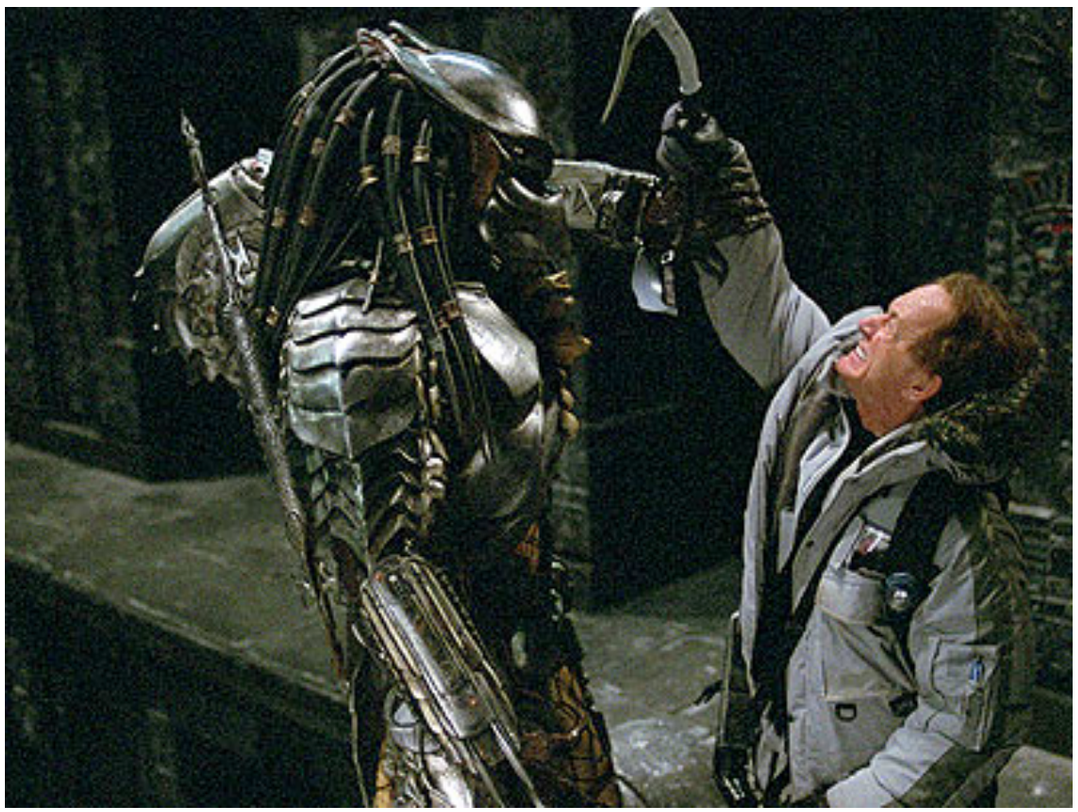
- ICES: time running out!
- Hour Exam 3: next class meeting--in 48 hours!

  details on course website

Last time: The Big Rip and Other Cosmic Fates

Today: Aliens





just so we are totally clear...

Hour Exam 3
in class
this Wednesday!
48 hours from now!

This will conclude the course
Nothing during finals week

ICES

ICES course evaluation is now available, done online.

Please do it! I appreciate it!

So: have you done it yet?

(A)Of course! Future generations of Illini will thank me!

(B)Umm, not yet, but I'll do it today

(C)No, after hearing about all of the ways Astronomy can kill me, I figure there's no chance there will be a U of I by the time this course is taught again. Plus I don't care about future generations, and 5-10 minutes of my time is too much to give.

Imagine

Astronomers notice something bright in gamma-rays moving into the Solar System.

The object is changing course!

Contact! But it isn't responding to our hails.

The object passes by the asteroid belt, but then starts to move out of the Solar System.

Excitement dies down, but a year later, an asteroid starts to change orbit and move toward Mars.

The asteroid has factories and "lands" on Mars.

Robotic spiders are building more and more factories, and with our orbiting spacecraft, we watch.

Imagine

Within a few years, the surface of Mars is picked clean, as micro-factories replicate huge numbers of alien robot-like organisms and spacecraft.

A year later, objects start to lift off from Mars, and they are coming toward Earth!

As they land, there is nothing we can do.

They begin to destroy the surface of the Earth, making more replicates of themselves.

As you are ripped apart for your heavy elements, you wish you had filled out your ICES form for Brian's class

Are We Alone?

- It's a great time to think about this question!
- In 1995, we knew of 9 planets. Now, in 2012, we know of 763 confirmed exoplanets!

http://exoplanet.eu

- In the near future, NASA missions may find life on Titan or Europa, evidence of life of Mars, or image Earth-like planets around nearby stars.

- Can we answer arguably the biggest astronomical question of all time: Are we alone?

iClicker Poll

Do you think we are alone? Have we been visited by spacefaring aliens?

a) **No: we are alone**, there is no life elsewhere

b) **Yes, there's life elsewhere**, but we have **not been visited**

c) **Yes, ET has been here!**

d) **Maybe**, how am I supposed to know?!?

Numerically Challenged

In the Universe, the number of stars is greater than the number of grains of sand on all of the beaches of the Earth.

Each of these stars may have planets.

Or only 0.0001%?

Is it sensible to think that life only exists on Earth?

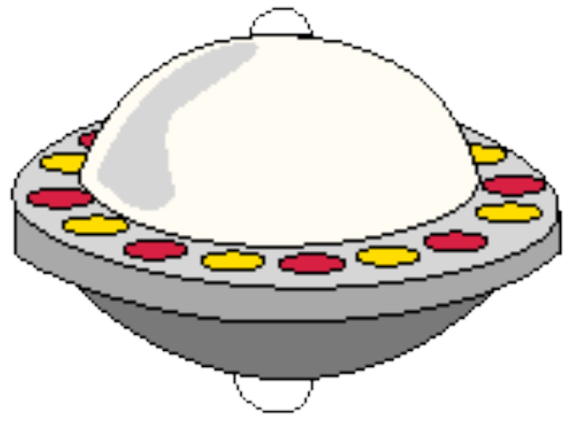
Aliens?

We have been bombarded by aliens in the media– all types.

No surprise that close to half of all Americans believe in aliens.

Have we been visited by ETs?

"Extraordinary Claims Require Extraordinary Evidence"



Drake Equation

Frank
Drake

N =

# of advanced civilizations we can contact in our Galaxy today

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 in our Galaxy today	Star formation rate	Fraction of stars with planets	# of Earthlike planets per system	Fraction on which life arises	Fraction that evolve intelligence	Fraction that commun-icate	Lifetime of advanced civilizations
	stars/ yr	systems/ star	planets/ system	life/ planet	intel./ life	comm./ intel.	yrs/ comm.

Not a real equation, but a way to guide our thinking about the questions.

R_*

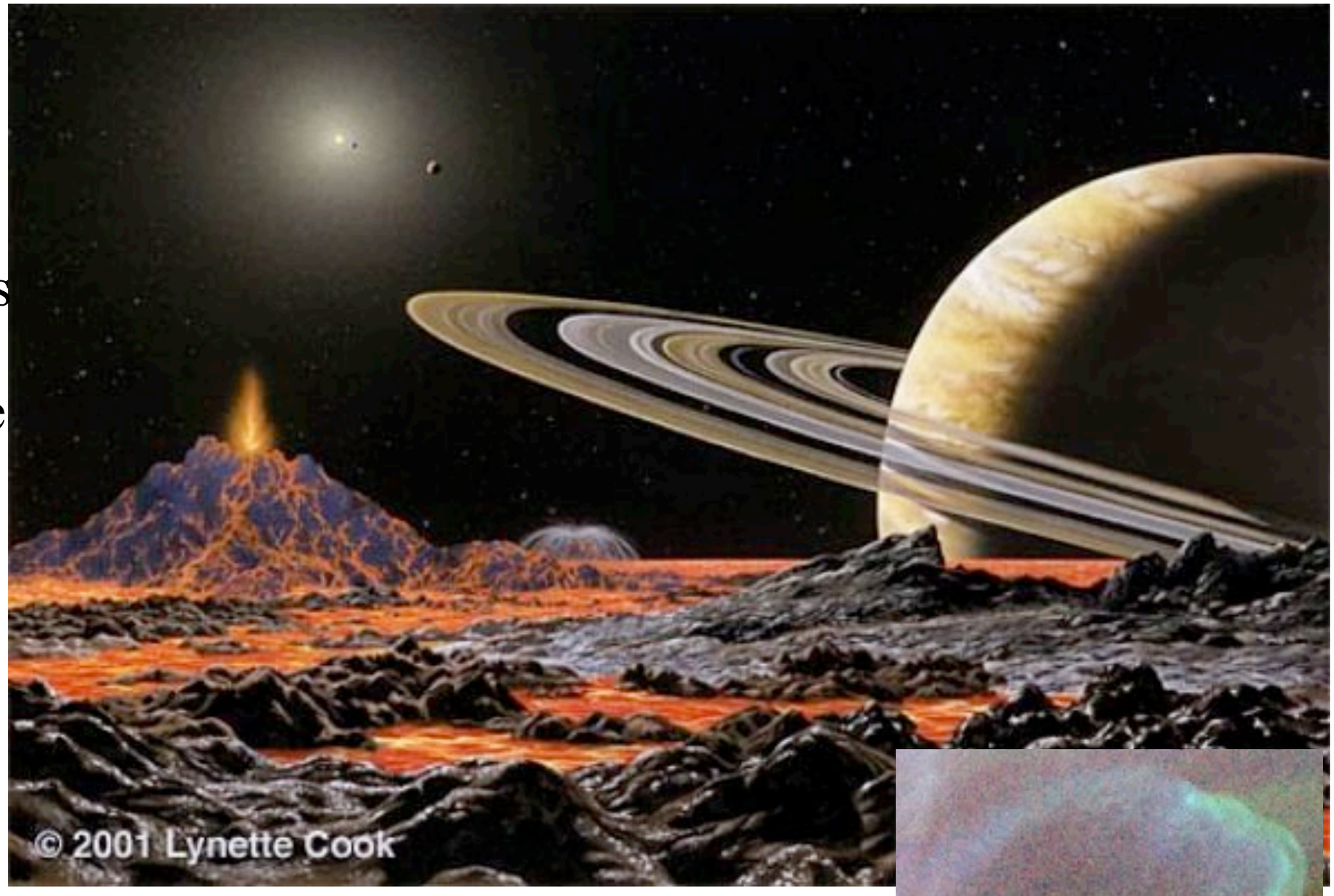
There are perhaps tens to hundreds of billions of galaxies

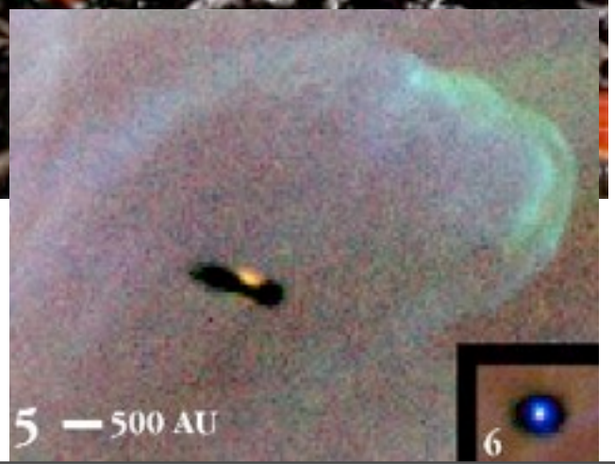
- Each with hundreds of billions of stars
- Age of Universe is 13.7 billion years

Probably best known number.

f_p: Other Planets, Other Stars

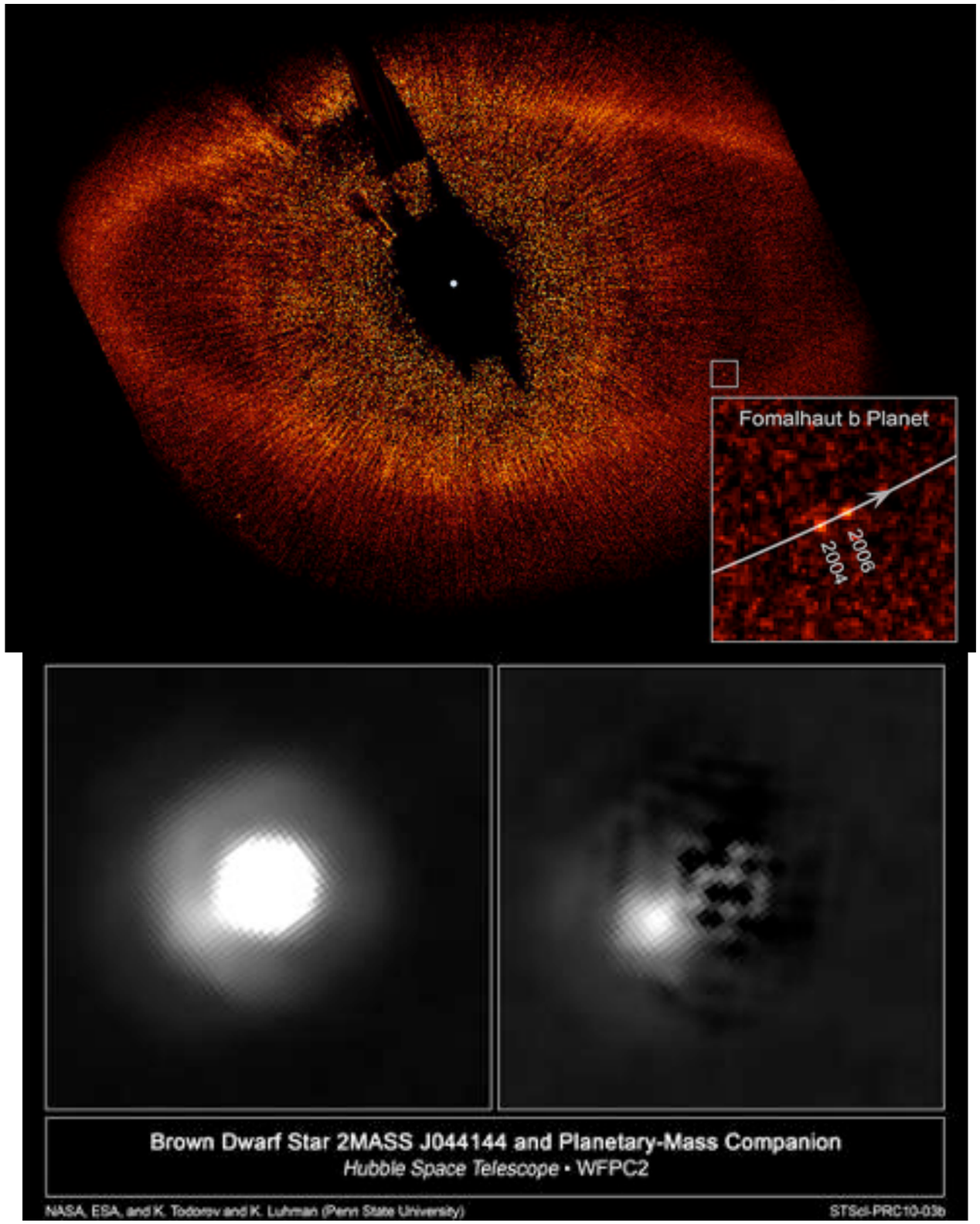
47 Ursae Majoris System– 51 light years away (near the Big Dipper). 13 years of data has shown 2 planets– 1 Jupiter like and 1 Saturn like.

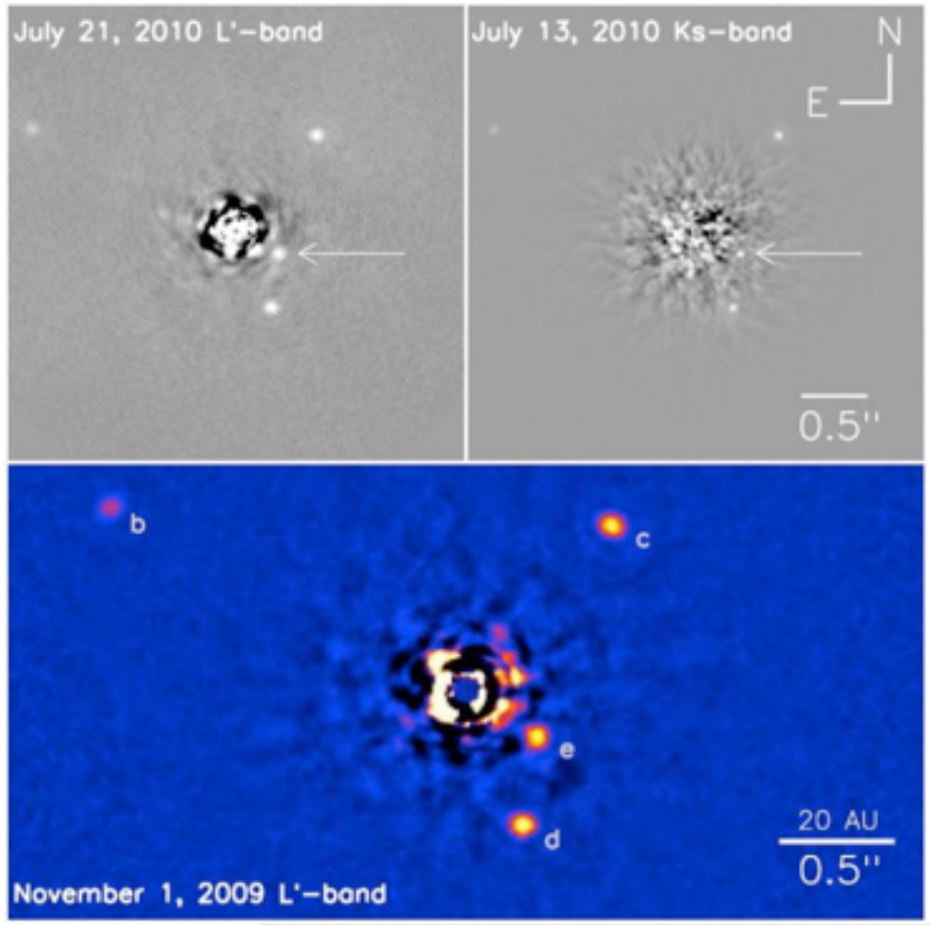


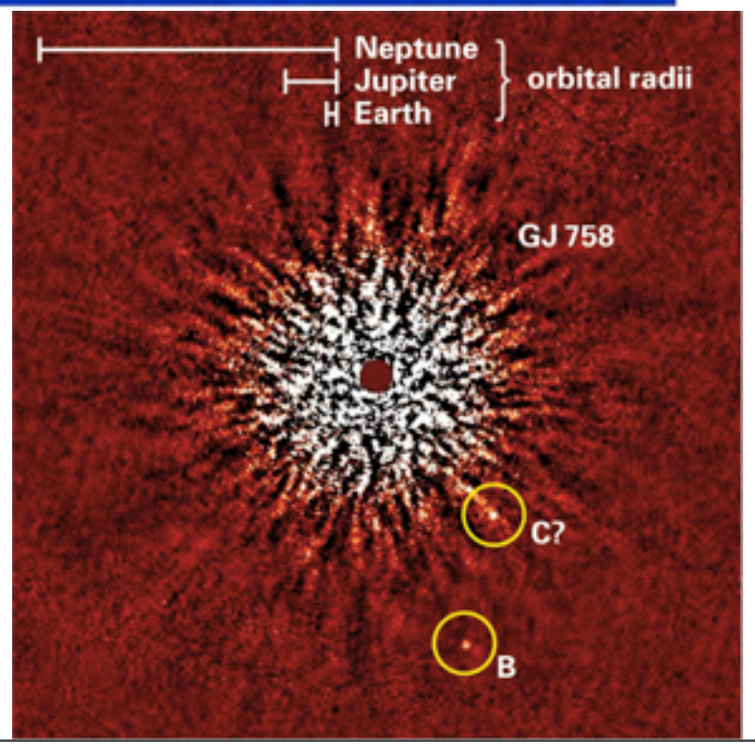


Wow! Among the most similar to our own system

We already have Images of 31 Exoplanets!!!!







Kepler Mission

Kepler: NASA **planet-finding satellite**

- has been in operation for > 3 years
- huge success!

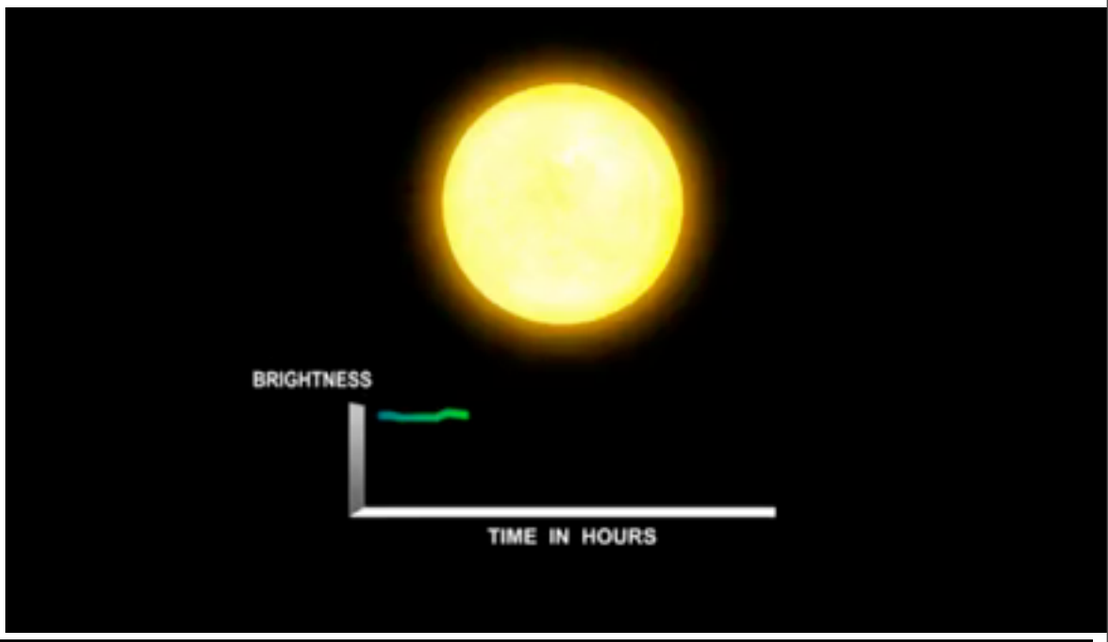
>2300 planet candidates

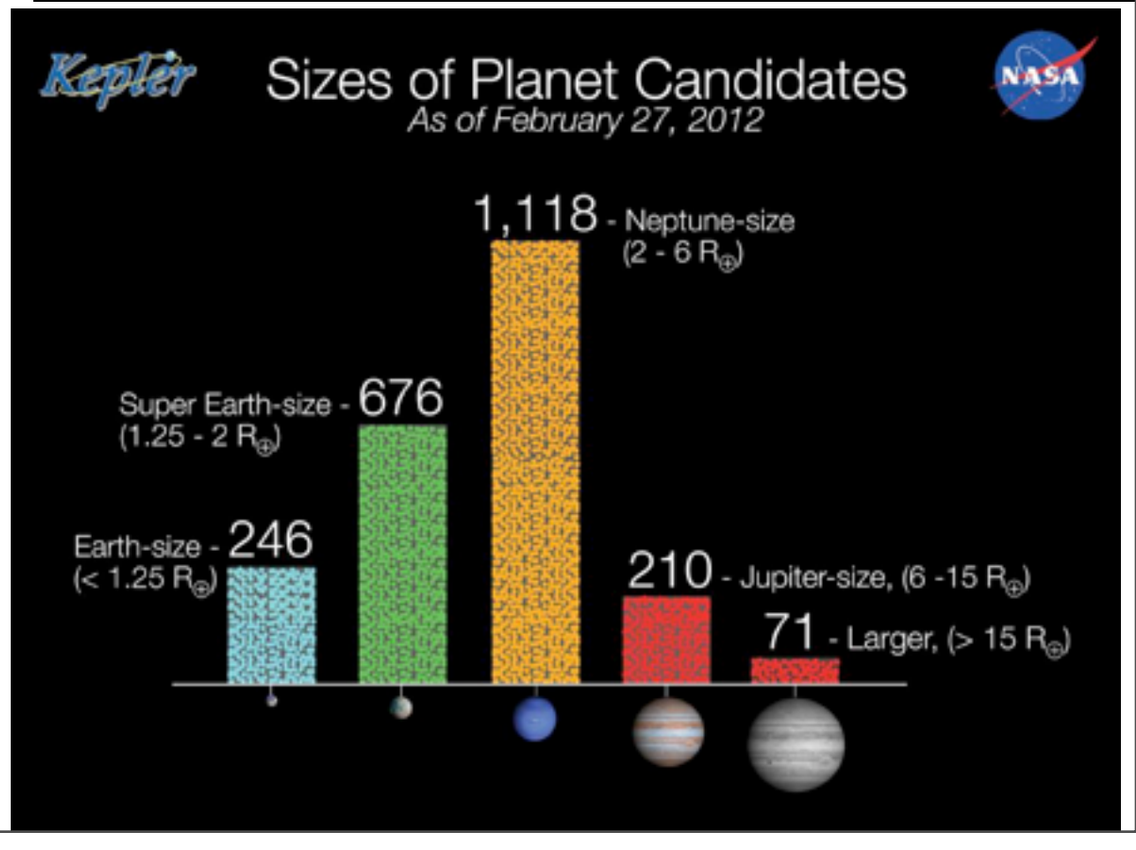
- verification ongoing

first confirmed **Earth-sized planets**

first confirmed **planets in habitable zone**

Results suggest **planets very common**--possibly **all** stars have planets of some kind!





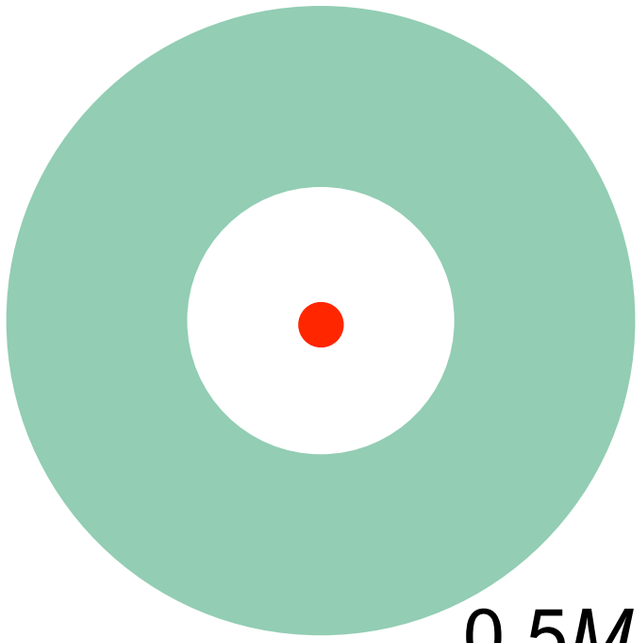
n_e: Habitable Zones–
Are you in the Zone?

Long living star

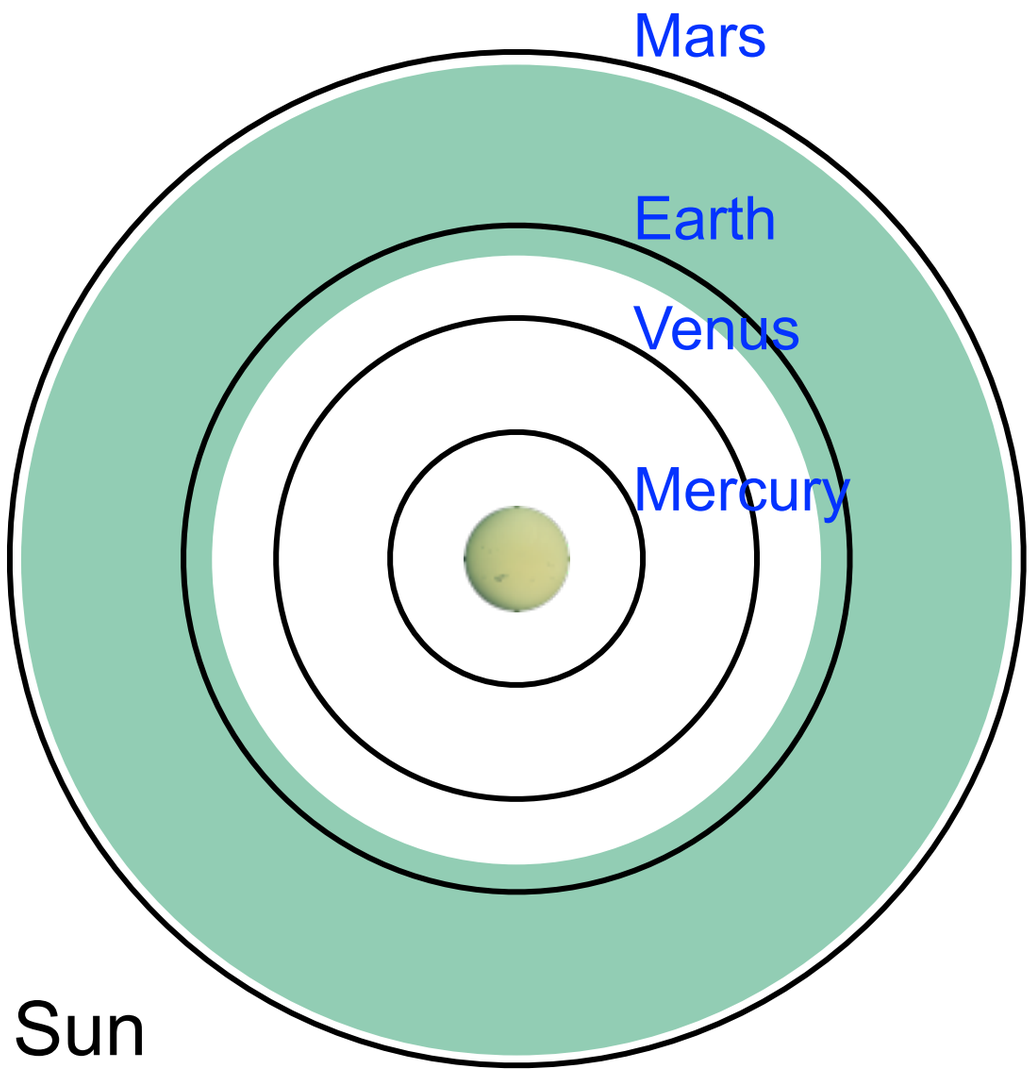
Planets with stable orbits (thus stable temps)

Liquid Water

Protection from UV radiation



$0.5M_{\mathrm{Sun}}$ star



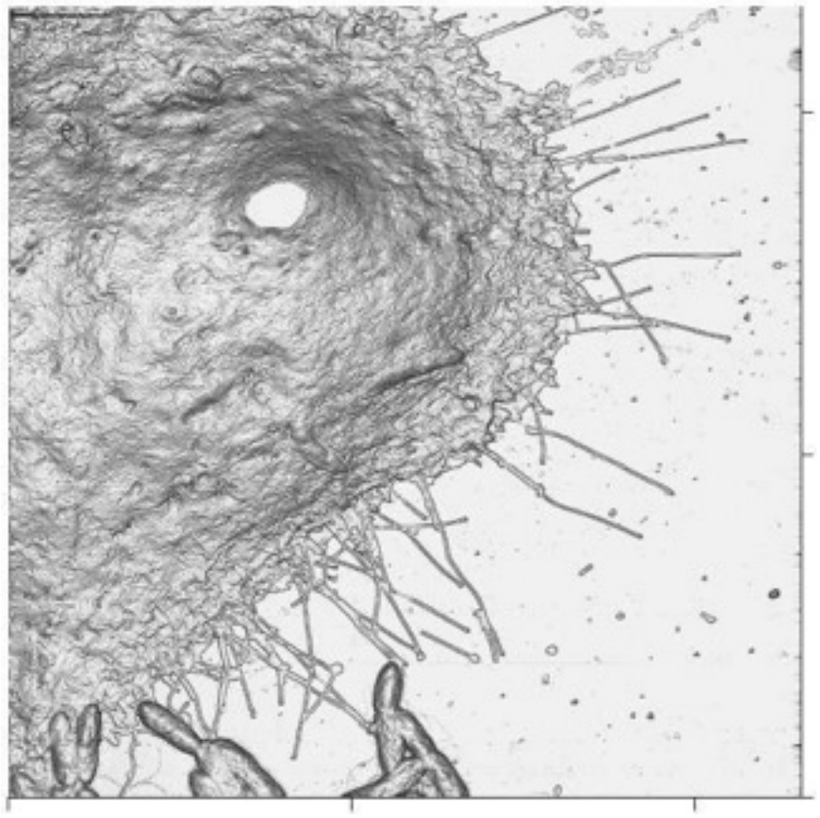
The Sun

f_l: Cosmic Imperative?

Is life a cosmic imperative?

Just like gas forms galaxies, and in galaxies stars and planets form, do chemicals on some planets form molecules that lead to life?

All Made from the Same Stuff



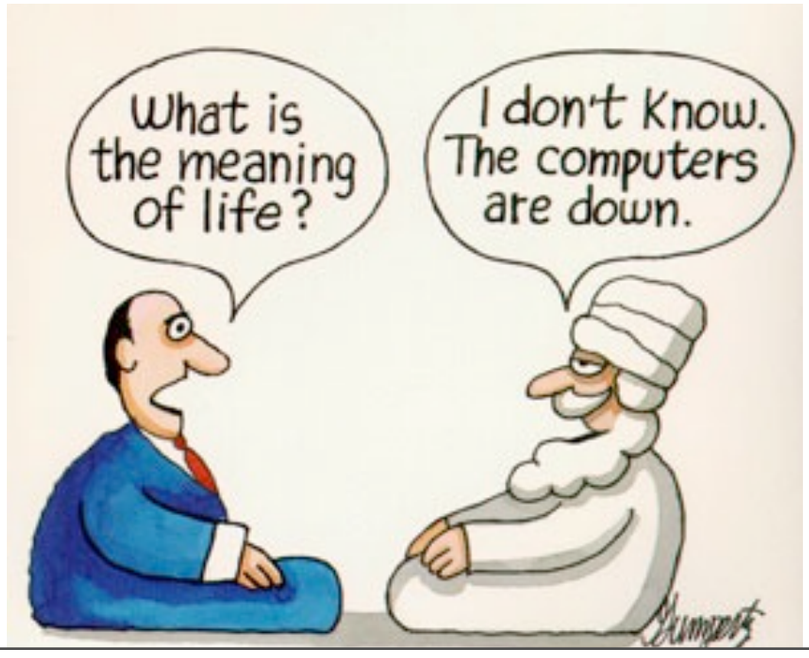
What is the Earth made of?

The makeup of the Earth is very different than our makeup (all life).

HONC are the elements of life.

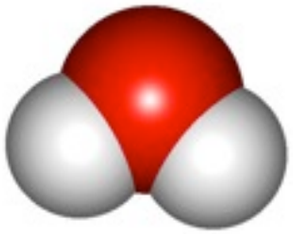
- **Hydrogen: Big Bang**
- **Oxygen: high-mass stars**
- **Nitrogen: intermediate-mass stars**
- **Carbon: intermediate-mass stars**

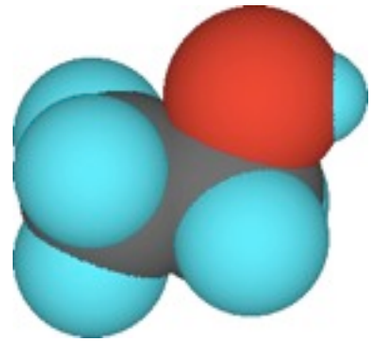
We are star stuff!

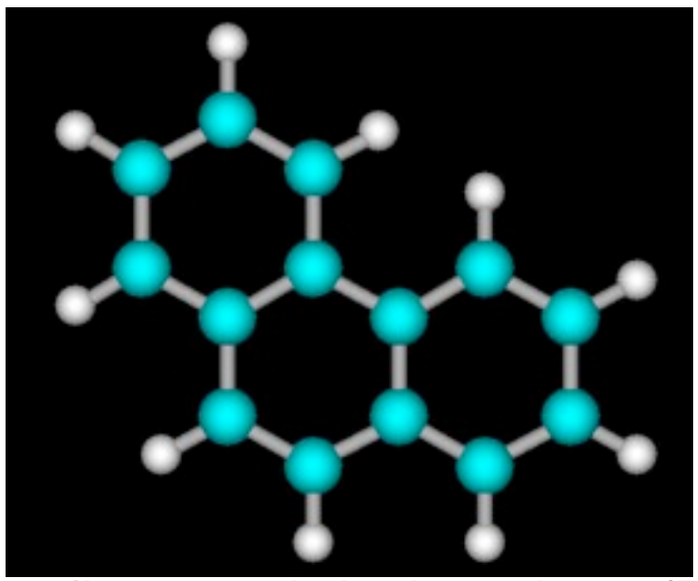


Molecules in Space!

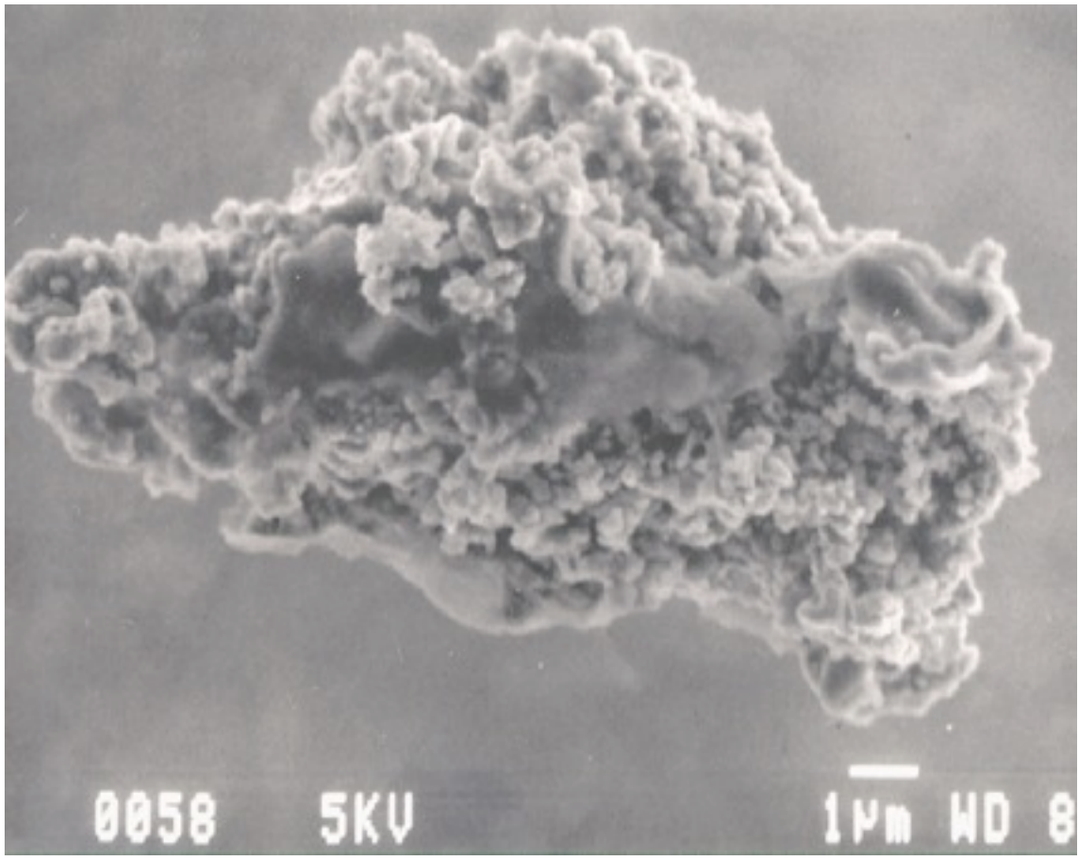
- Molecules (e.g.)
  - Carbon monoxide (CO)
  - Water (H_2O)
  - Ammonia (NH_3)
  - Formaldehyde (H_2CO)
  - Glycine (NH_2CH_2COOH)?
  - Ethyl alcohol (CH_3CH_2OH)
  - Acetic Acid (CH_3COOH)
  - Urea [$(NH_2)_2CO$]
- Dust particles
  - Silicates, sometimes ice-coated
  - Soot molecules







Polycyclic aromatic hydrocarbons (PAH)

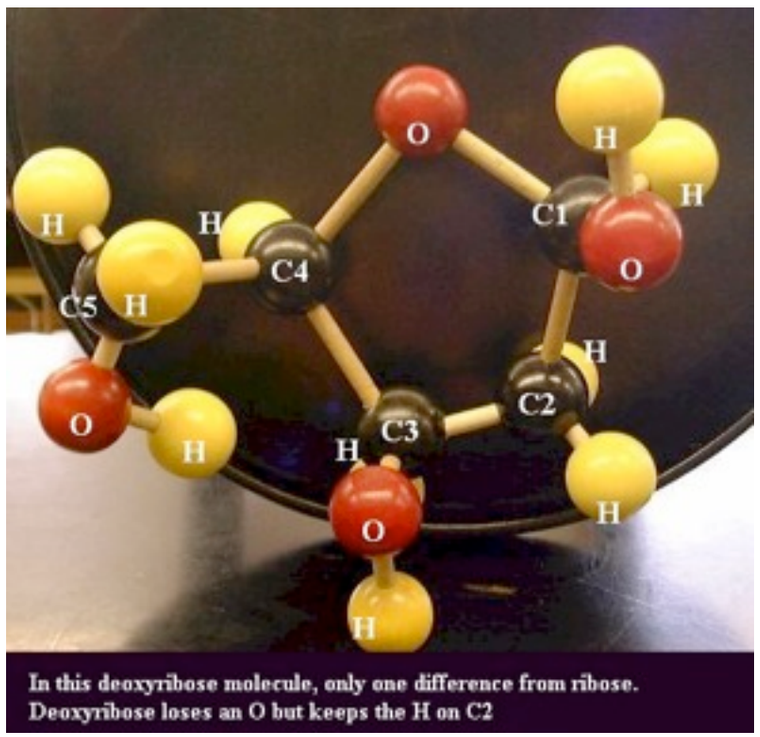


Dust particle (interplanetary)

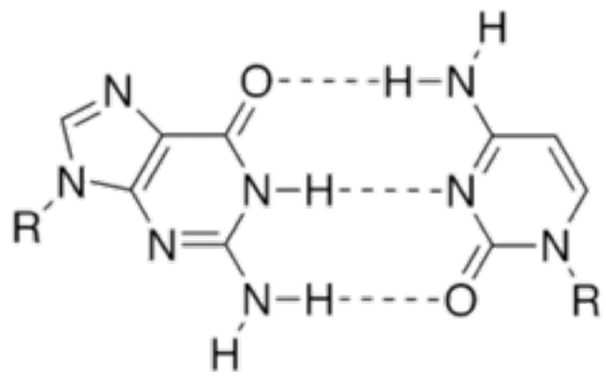
Life Materials

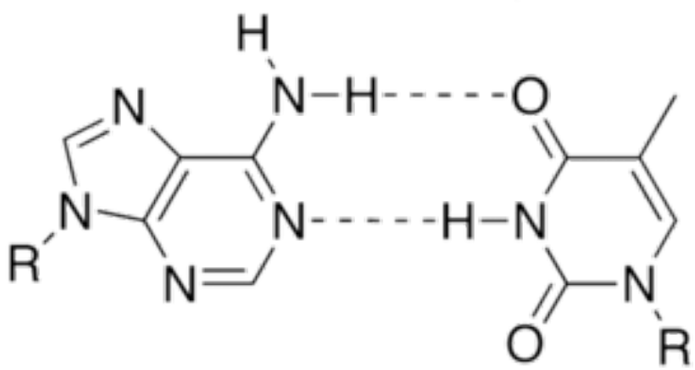
Essential (?) life components:

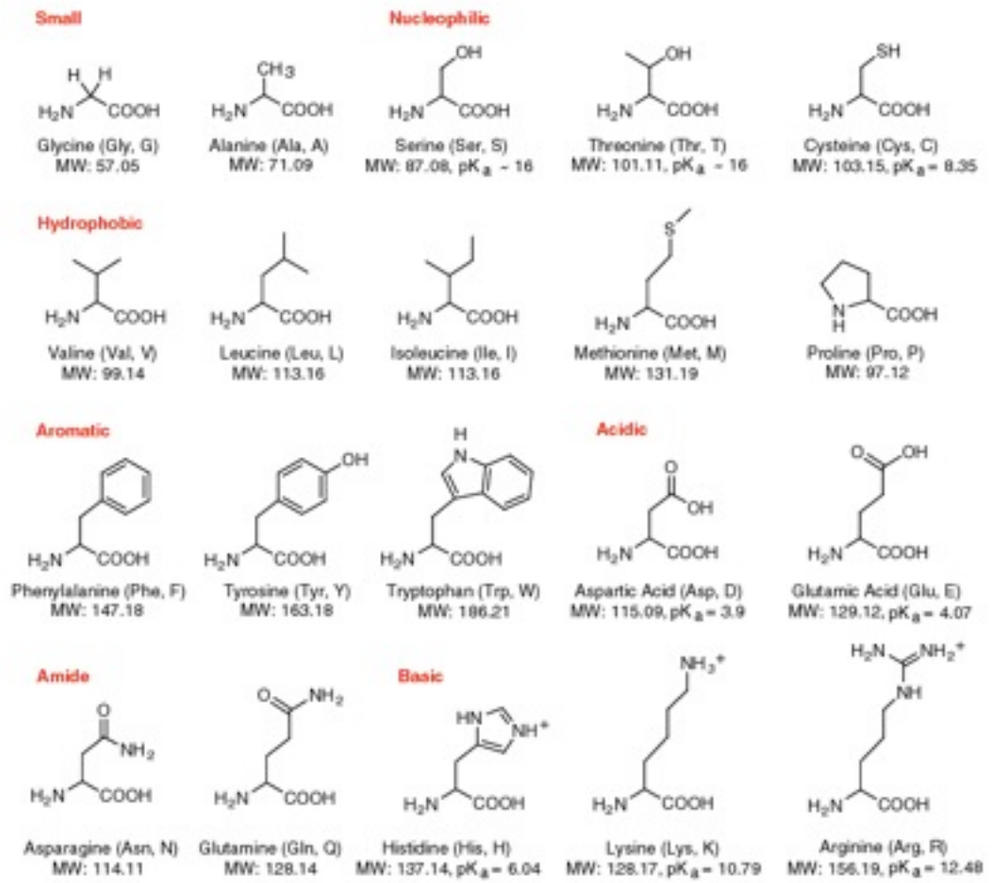
- **DNA: sugar, 4 bases, and phosphorous**
- **Proteins: 20 amino acids**



In this deoxyribose molecule, only one difference from ribose. Deoxyribose loses an O but keeps the H on C2







Miller and Urey Experiment

- Testing chemistry on the early Earth– no oxygen.
- Can we make the important molecules of life easily?
- ALL 20 amino acids needed for life can form with water and an energy source under the right conditions.

http://physicalsciences.ucsd.edu/news_articles/miller-urey-resurrected051903.htm

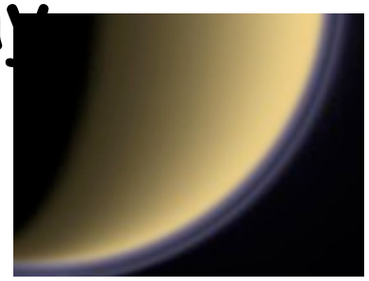
Life in the Solar System

No conclusive evidence exists for life in our solar system besides on Earth

But, possibilities exist for life

- **Venus** may have microbial life high in the atmosphere, fleeing the high temperature of the surface.
- **Mars** may have some microbial history linked to water, and perhaps some subsurface life.
  - Maybe Martian life seeded Earth?

- **Europa** (Jupiter moon): sub-crustal oceans may harbor life,
  even fish-like life.



- **Titan** (Saturn moon): very interesting
  - Thick atmosphere

Life on Earth

Everywhere you look, there is life.

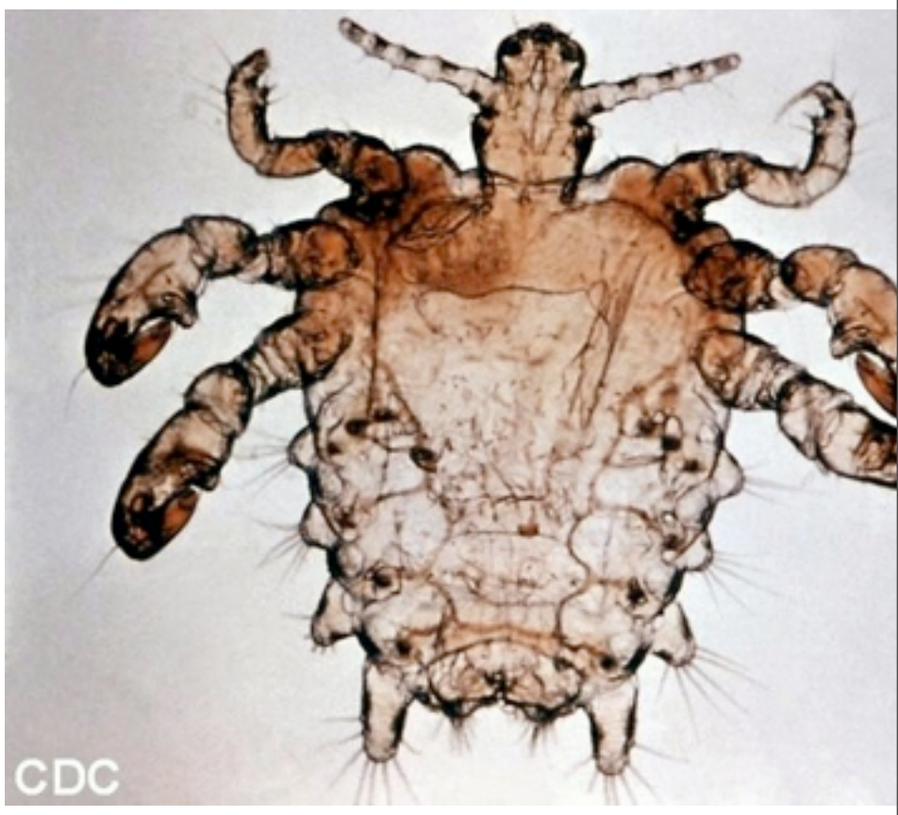
Ubiquitous.

Places that you would have thought lethal has prolific life!

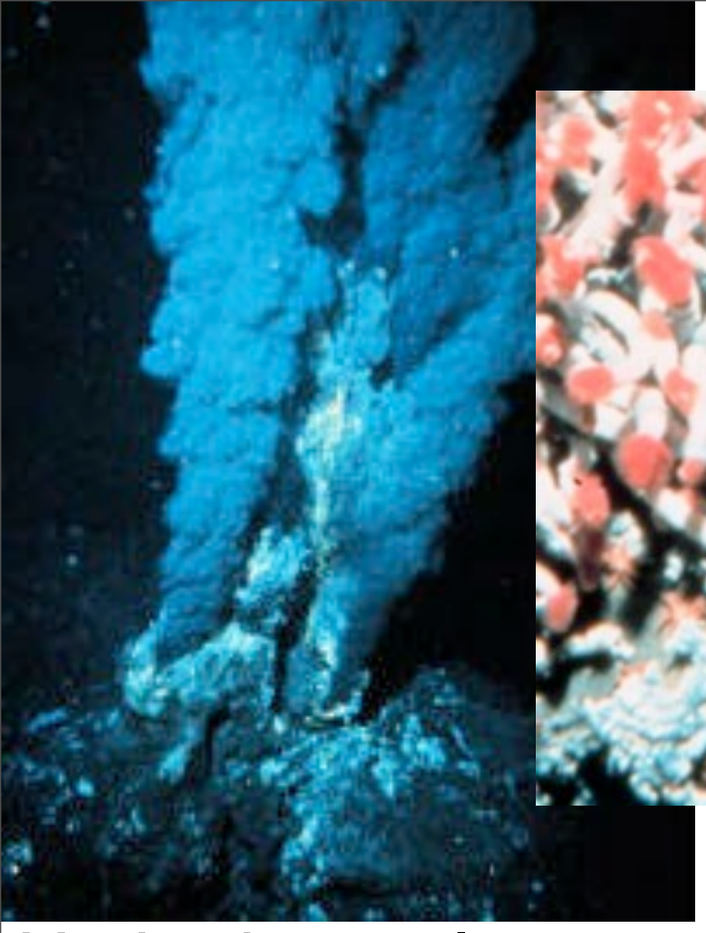
Life is everywhere on Earth!

- **Earth not fine-tuned for life.**
- **Life was fine-tuned for Earth.**

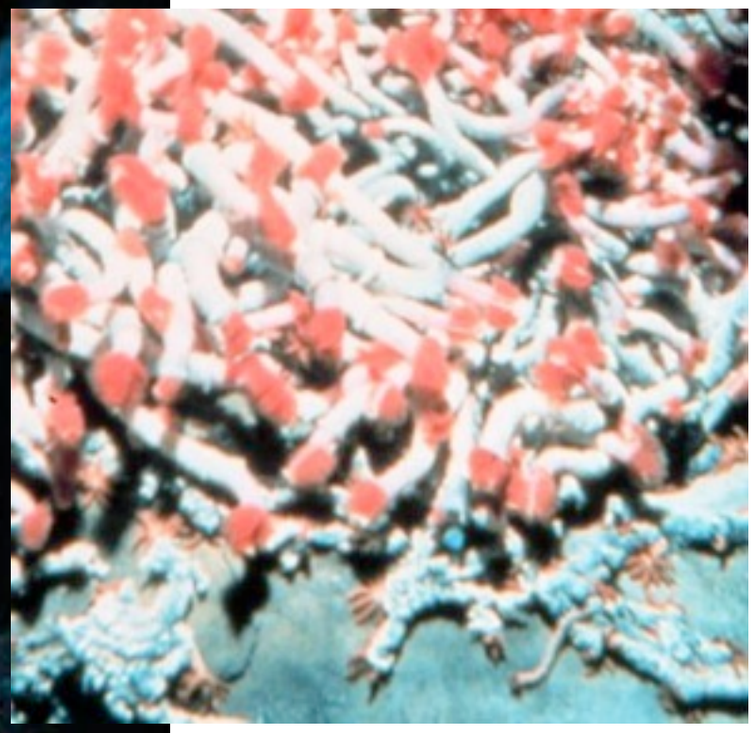
Why not the Galaxy?



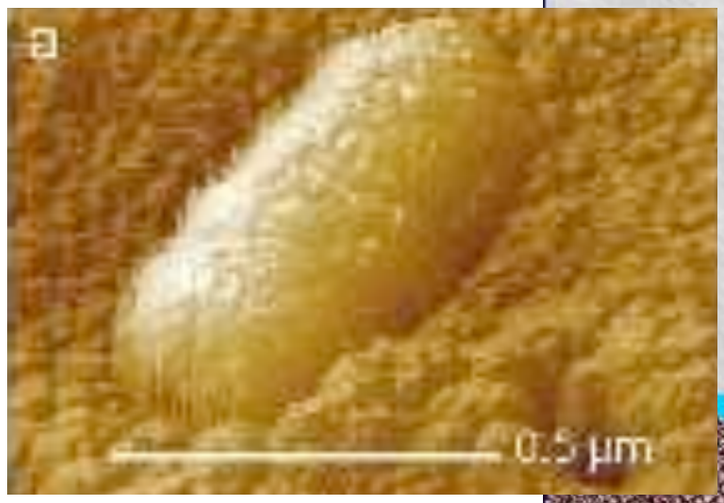
The human lice! Also called crabs.



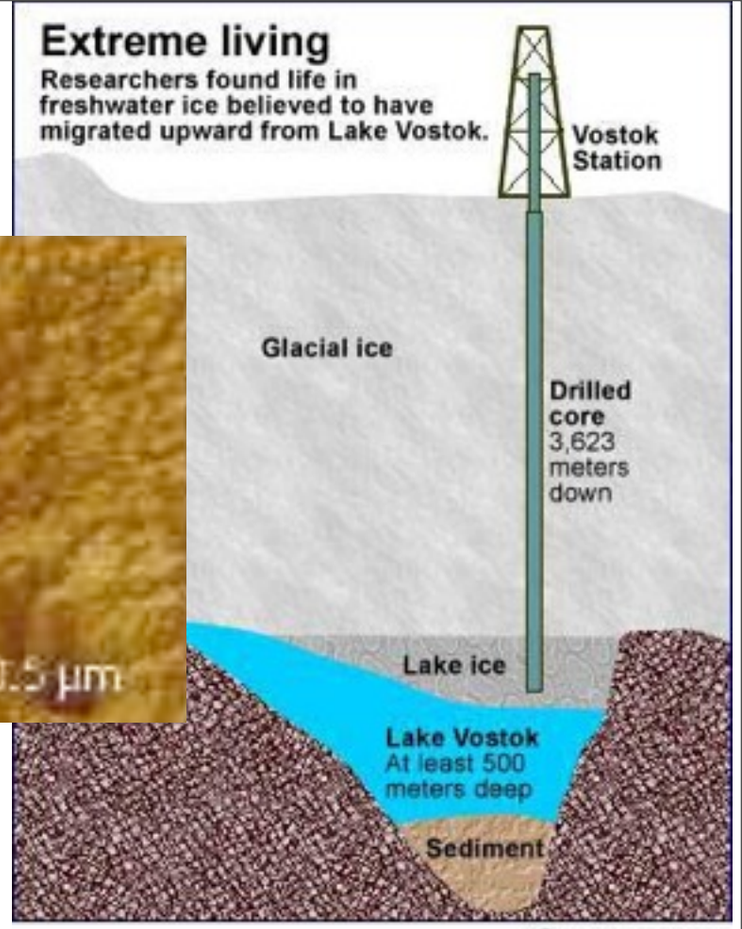
Hydrothermal vent

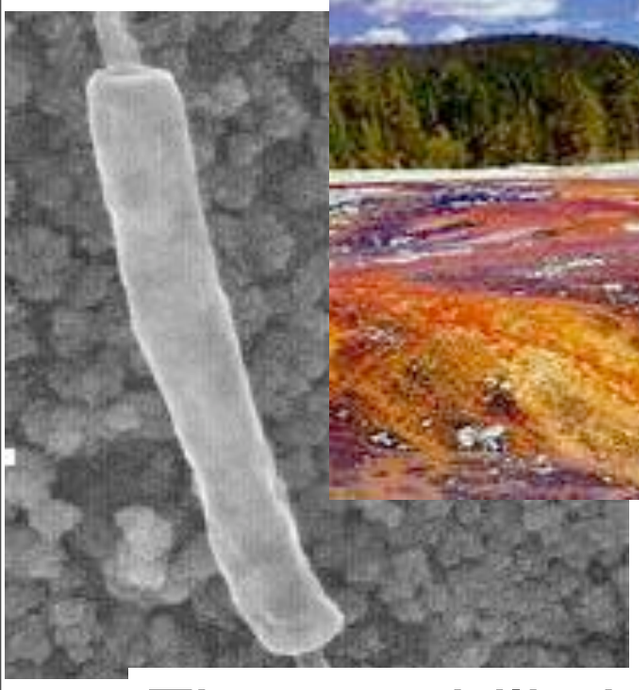


Tubeworms



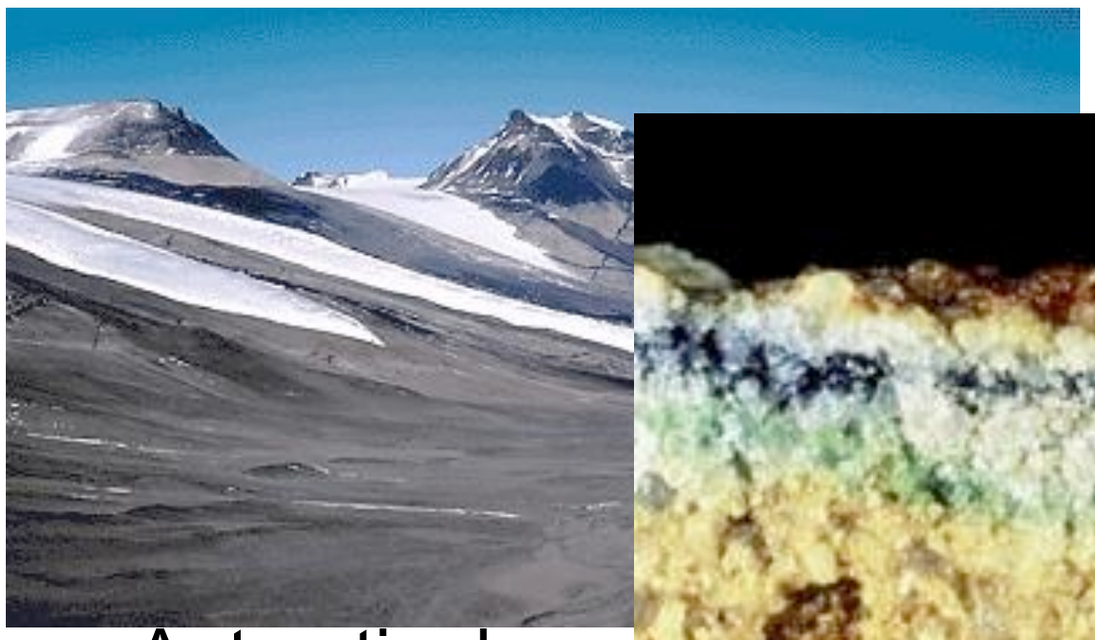
Lake Vostok - Antarctica





Thermophilic bacteria

Hot springs



Antarctic dry valley

Cryptoendoliths

f_i: Intelligence

Intelligent life is a very recent development on Earth with the emergence of the primates, hominids, and H. sapiens.

Everyone agrees that this particular evolution will not occur on other planets.

But, will the characteristics of H. sapiens be common to human-like intelligence?

- Manipulative organs– hands
- Walking upright?
- Is tool use and larger brains associated with walking upright?
- Pair bonding?
- Human brains quadruple in size after birth compared to other primates which double.

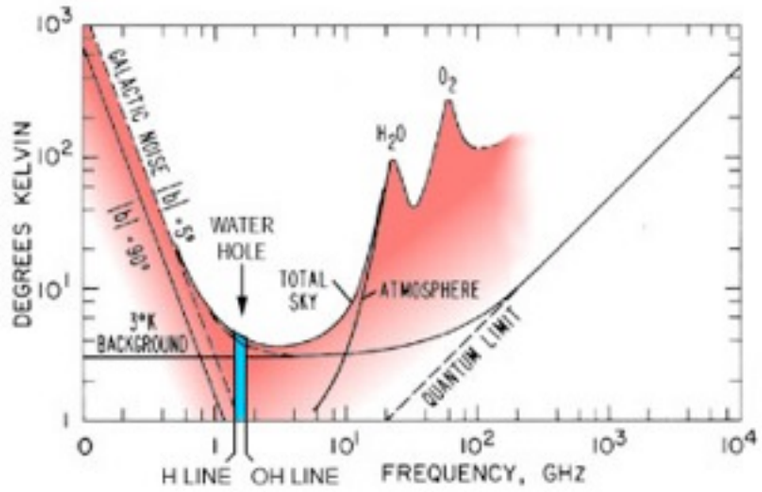
f_c : Galactically Aware

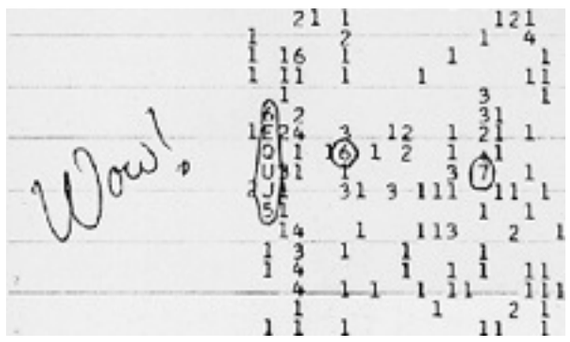
Realization that extraterrestrial life is possible.

The urge and technology to communicate.

Search problems

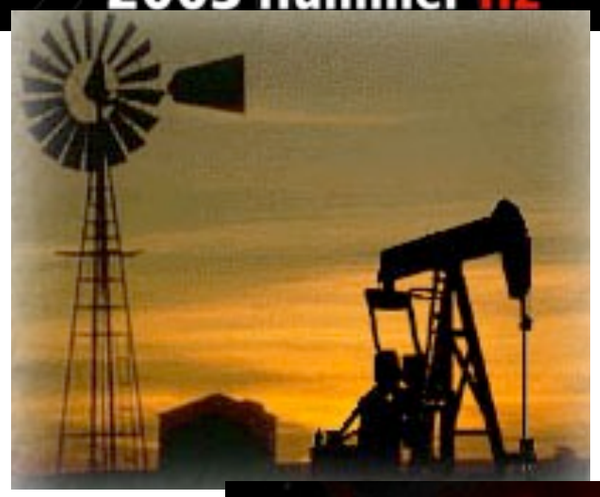
- Where to look
- What frequency/wavelength to look
- What code to use
- Etc…





L: Lifetime


The 2003 Hummer H2

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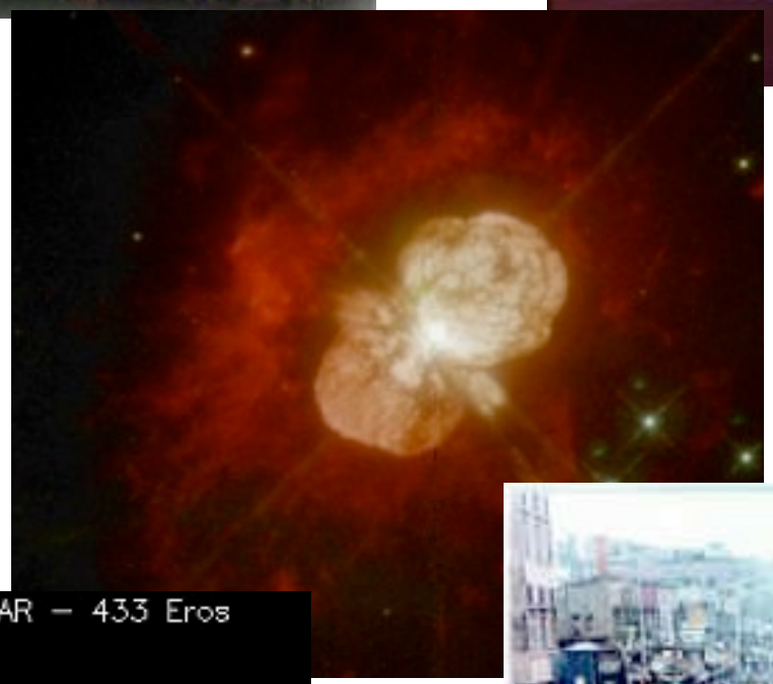
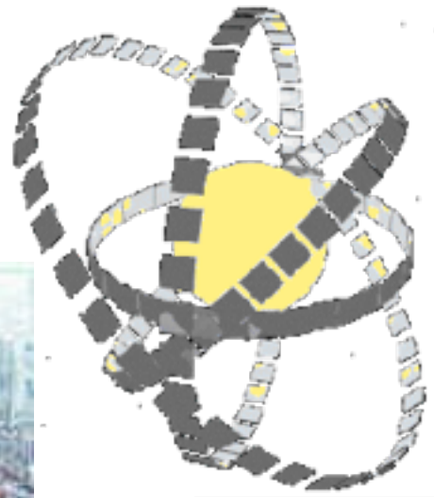
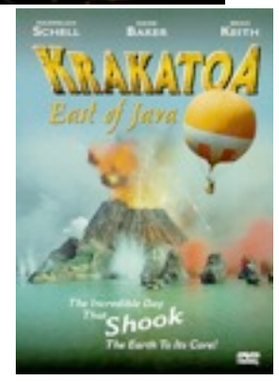



NEAR – 433 Eros
Feb 12 2000 00:58:00




KRAKATOA
East of Java
Shook

What is L?

How long on average can an advanced civilization exist?

- Short Term (100-1000 yrs)
  - Give up on communication due to budgets.
  - Depletion of resources.
  - Population.
  - War.
- Long Term (100,000 to 5 Byrs– age of galaxy is ~13 Byrs yrs and we took nearly half of that to evolve)
  - Stellar Evolution.

Don't forget the random volcano, asteroid, or supernova.

Still in many cases an advanced civilization may be prepared for many of the issues!

Drake Equation For Optimist

$= 2.5 \times 10^{11}$

Communicating Civilizations

62.5% of all stars in our Galaxy!








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

# 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 commun-icate	Lifetime of advanced civilizations
	50	**1**	**1**	**1**	**1**	**1**	**5×10^9**

Birthrate of 50/year!

Drake Equation
For Pessimist

= 0.0000075

Communicating Civilizations

Must wait 10^7 years for one!








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

# 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 commun-icate	Lifetime of advanced civilizations
	5	**0.1**	**0.15**	**0.01**	**0.01**	**0.01**	**100**

Birthrate of 7.5×10^{-8} /year!

Drake Equation For Average

= 930,000

Communicating Civilizations








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

# 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 commun-icate	Lifetime of advanced civilizations
	10	**0.5**	**0.89**	**0.5**	**0.7**	**0.6**	**1×10^6**

Birthrate of 0.001 /year!

Drake Equation
For Drake (1961)

= 10

Communicating Civilizations








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

# 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 commun-icate	Lifetime of advanced civilizations
	10	**0.5**	**2**	**1**	**0.01**	**0.01**	**10000**

Birthrate of 0.001 /year!

Where are they?

How to Communicate with ET?

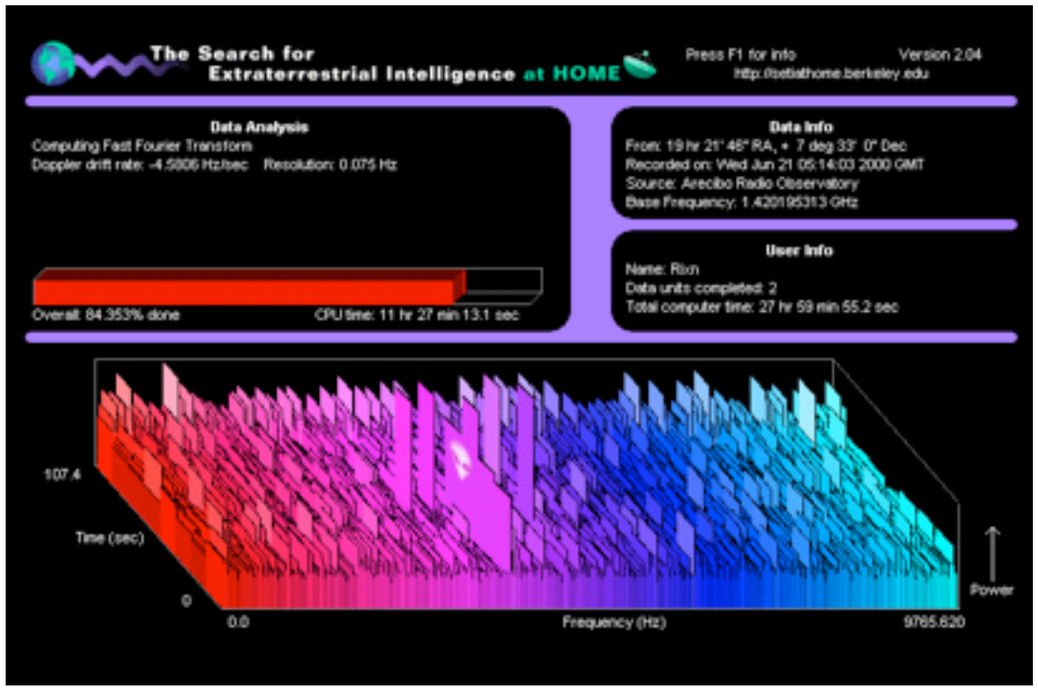
If ETs are out there, how do we go about detecting our neighbors?

Are we seriously sending out messages now?

No.

We are relatively a young civilization, with radio technology for only a hundred years.

Right now, we are mostly a passive “lurker” civilization.



Interstellar Travel

But, what if all communication with ET fails?

- Wrong frequencies.
- Everyone is listening and no one is broadcasting.
- We fail to recognize the signal.

We can go visit them or the microbes. "To boldly go…"

BUT, the distances are huge!

Nearest star is 4.3 ly away or around 4×10^{13} km!

40,000,000,000,000 km! 40 TRILLION km!!!

Our fastest object, Voyager would take nearly 100,000 years

Problems to Overcome?

1. Space is Big.
   - Nothing we can probably do about this one.
2. Time.
   - Because of #1, interstellar travel would take a lot of time.
   - But arguably do-able.

     Maybe lifetime is expanded, generation ships, suspended animation, or intelligent robots.
3. Cost
   - Right now, colossal budget of a few trillion dollars. Impossible now, but in the future?
   - Medieval blacksmiths could have made an oil tanker, but too costly. 500 years later, piece of cake.
   - In future, cost of interstellar travel may also go down.

Future: Warp Drives?

Due to great distance between the stars and the speed limit of light, sci-fi had to resort to "Warp Drive" that allows faster-than-light speeds.

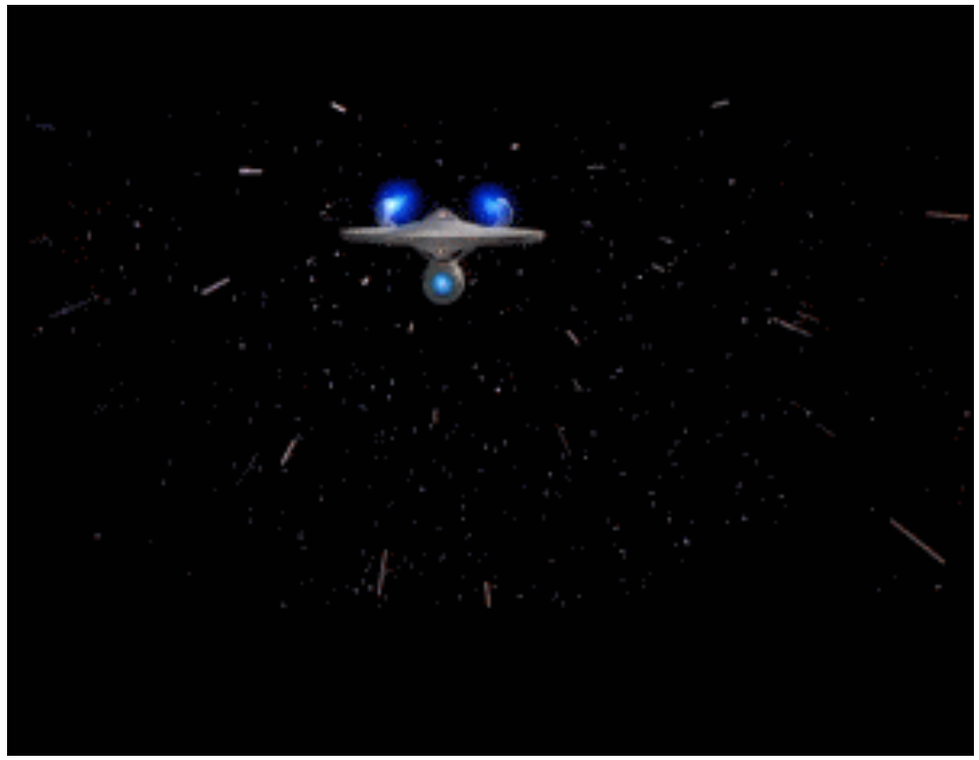
Currently, this is impossible.

It is speculation that requires a revolution in physics

- It is science fiction!

But, we have been surprised before…

Unfortunately new physics usually adds constraints not removes them.



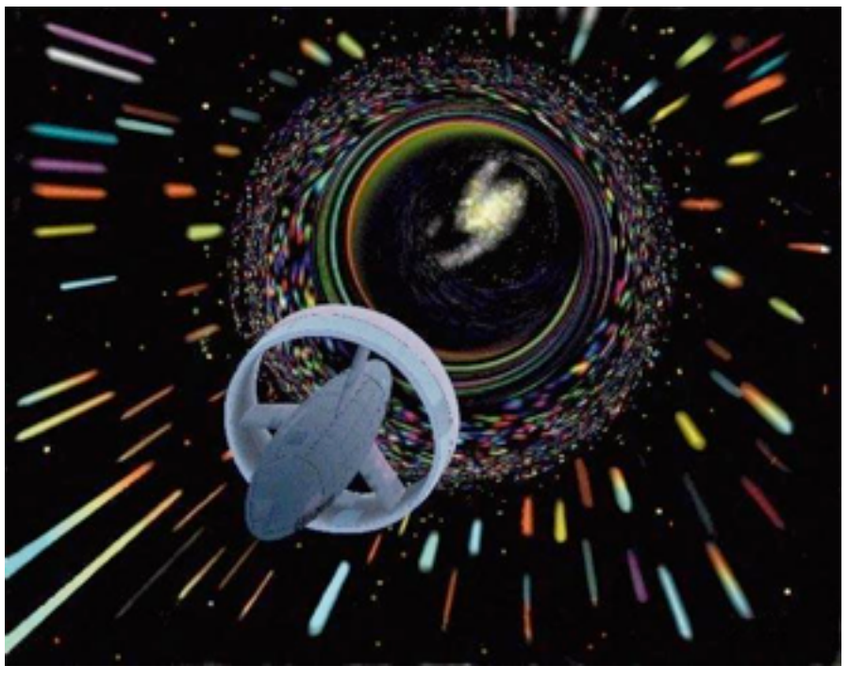
http://www.filmjerk.com/images/warp.gif

Getting Out of Here

Distances between stars are much greater than we can imagine– freaky big distances, plus difficult environment and time consuming makes interstellar travel hard to conceive.

SciFi books and movies have dramatized space travel to make it seem possible

- But, interstellar travel may never happen

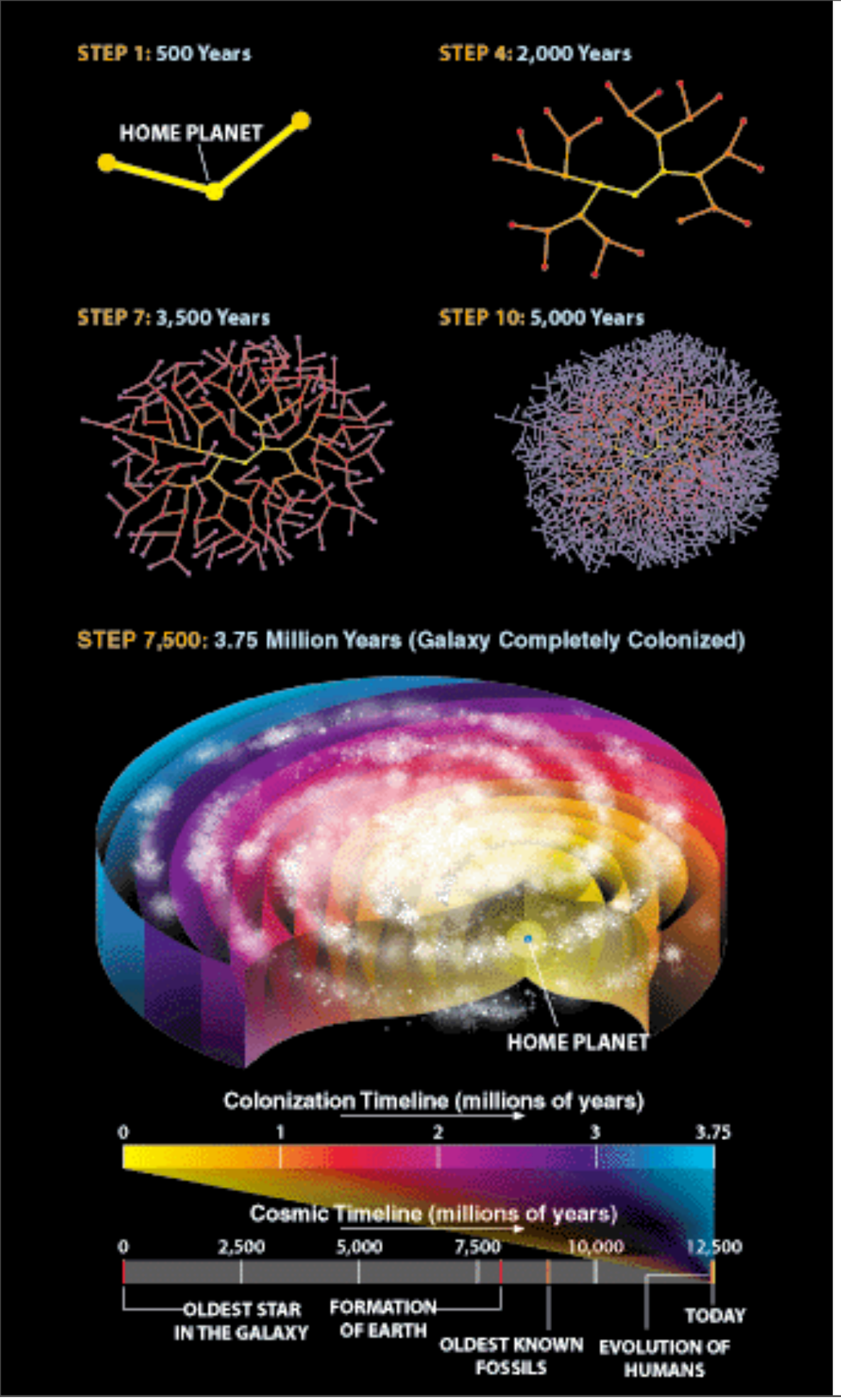


Galaxy Colonization

If the average Drake equation estimate is roughly right, there could be civilizations that are 1 billion years old!

Think of the accomplishments.

Even if interstellar travel is limited to 0.1c, civilizations with advanced telescopes could send colonizing craft to new "Earth-like" planets



Optimistic

Every 500 years, the colonization craft makes it to the next suitable solar system– small delay.

Colonization only takes about 4 million years!

The Fermi Paradox

The Drake Equation – Even for a few hundred technical civilizations.

Only 150 million years to colonize the Galaxy.

WHERE IS EVERYBODY?????

The Fermi Paradox

Given some ET civilizations, one of them must have developed earlier than we did.

So “Where are they?”

Even if interstellar travel is very slow and difficult, there has been a lot of time to do it.

Furthermore, many of the objections to interstellar travel do not apply to artificial intelligence (intelligent robots.)

Timescales

For pessimist: 150 million years to colonize the Galaxy.

For optimist: 4 million years to colonize the Galaxy.

This may seem like forever, but it is actually pretty tiny compared to the time it takes evolution (about 0.1%).

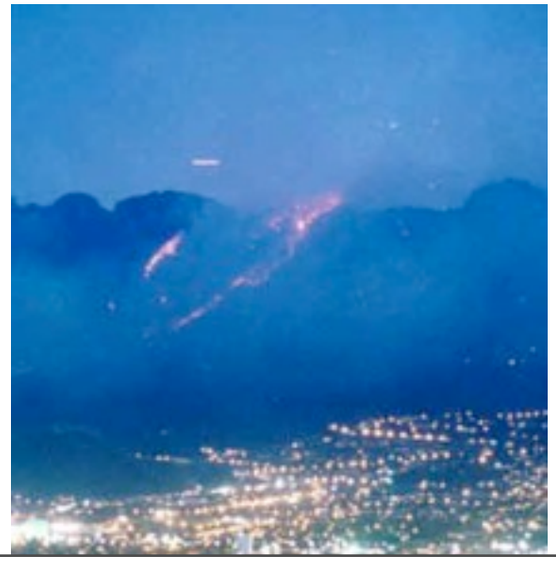
So, if we believe our condition, there should only be one intelligent family of species in our galaxy - whoever reached intelligence first should have spread everywhere before anyone else reaches intelligence.

This is the main point of the Fermi Paradox.

Problems?

Large number of sightings argues against alien spacecraft.

- Space is freaky big.
- There are extreme difficulties of interstellar space travel and the number of planets to explore.
- So, why would so many alien spacecraft be visiting the earth constantly?
  - There are other planets to check out.
  - What makes us so interesting?
  - We should not overestimate our significance.



Give Me Real Evidence!

Evidence:

- A piece of a probe or spaceship
- Some trace that can be uniquely linked to an ET probe
- Biological material.
- A reliable, logical calculation

That is the same we require of ANY scientific investigation

http://www.alien-ufos.com/images/ufos/miscufo4.jpg

Other Ideas: Space Probed

A single probe is constructed and dispatched to a nearby star system

It surveys the system in an intelligent and exhaustive manner

After which, the probe uses the energy and available raw materials of the system to reproduce itself .

Often called a Neumann Space Probe

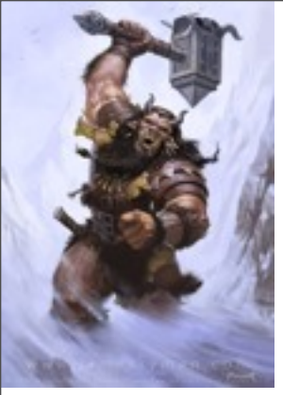
Neumann Space Probed

Dispatches its “children” onwards to repeat its mission in other star systems

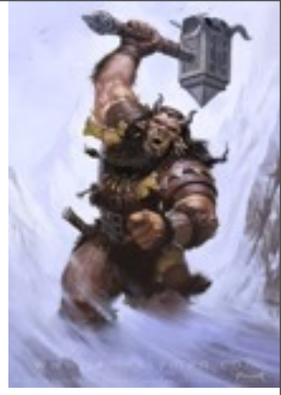
The parent probe is then able to choose whether it wants to stay in the system or not, depending on what it found

Armchair explorers

http://www.biochem.wisc.edu/wickens/meetings.html



Neumann Space Probe BERSERKERS!!!!!!



Self-Replicating Devices

Openly hostile to life forms

Out of control

Probe ecosystem?

Programmed to evolve?

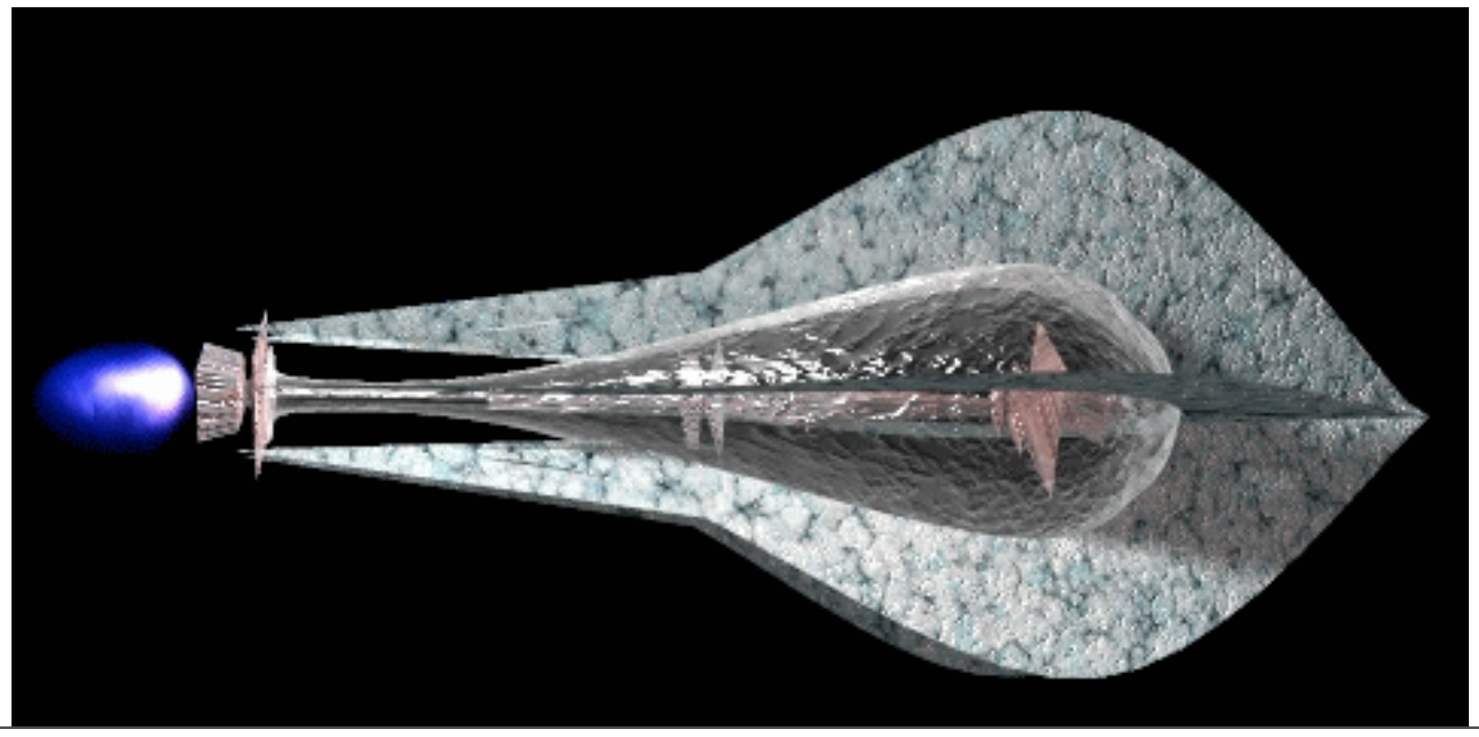
Neumann Space Probed

What if it's armchair generals instead of explorers.

Decide to change the galaxy by force?

What if programming goes crazy, and the objects decide to ignore the explore part and focus on only the replicate part?

Might be a larger possibility than we thought.



Mitigation

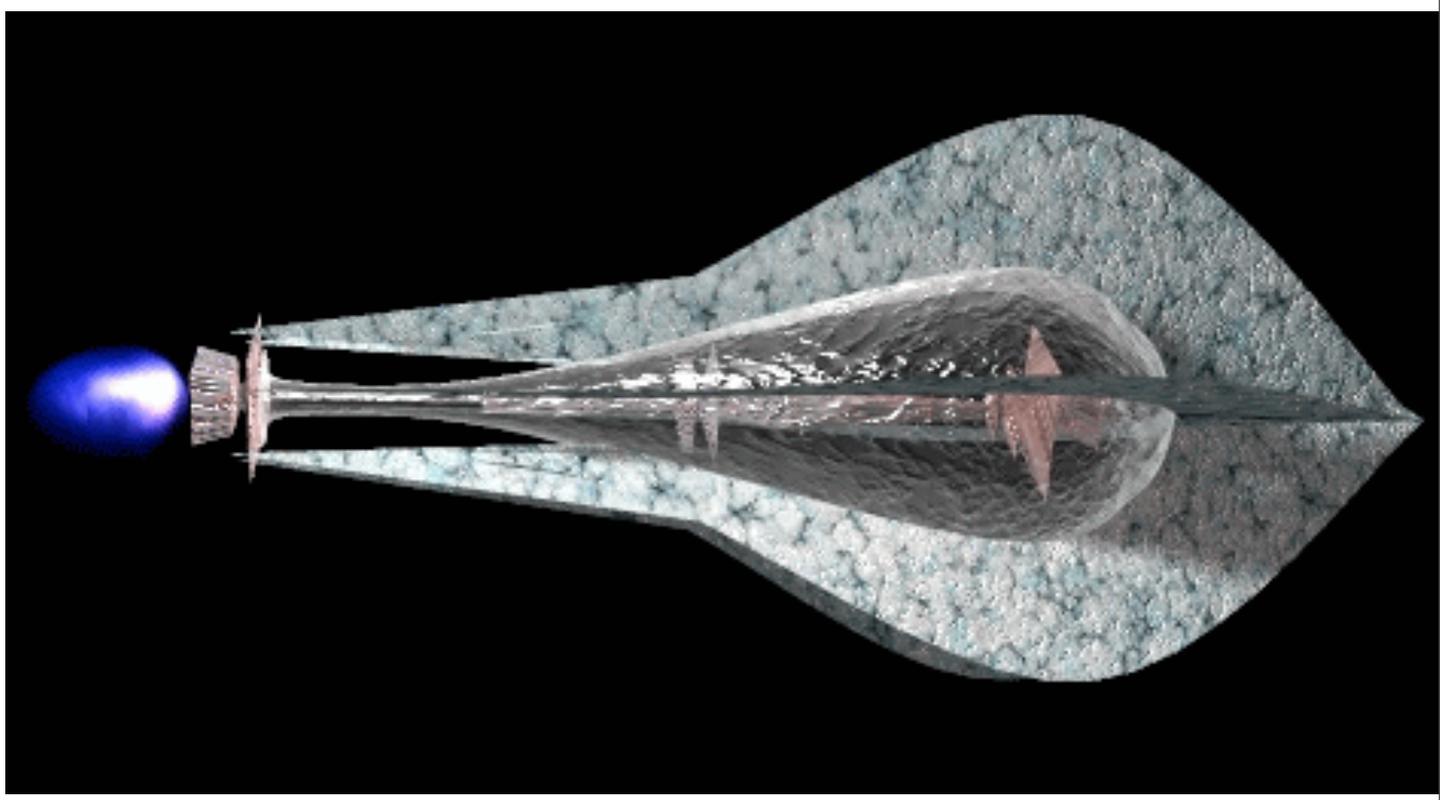
I dunno.

Send out our own probes?

Make sure to get vaccinated for space flu?

Destroy all life friendly planets in case they evolve after us?

I prefer to just explore the Universe, and let's see what's out there!



Imagine

Astronomers notice something bright in gamma-rays moving into the Solar System.

The object is changing course!

Contact! But it isn't responding to our hails.

The object passes by the asteroid belt, but then starts to move out of the Solar System.

Excitement dies down, but a year later, an asteroid starts to change orbit and move toward Mars.

The asteroid has factories and "lands" on Mars.

Robotic spiders are building more and more factories, and with our orbiting spacecraft, we watch.

Imagine

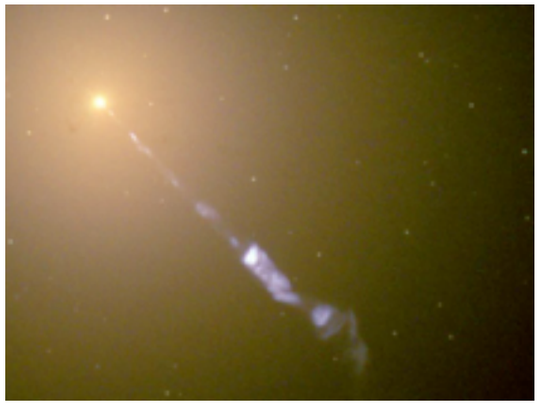
Within a few years, the surface of Mars is picked clean, as micro-factories replicate huge numbers of alien robot-like organisms and spacecraft.

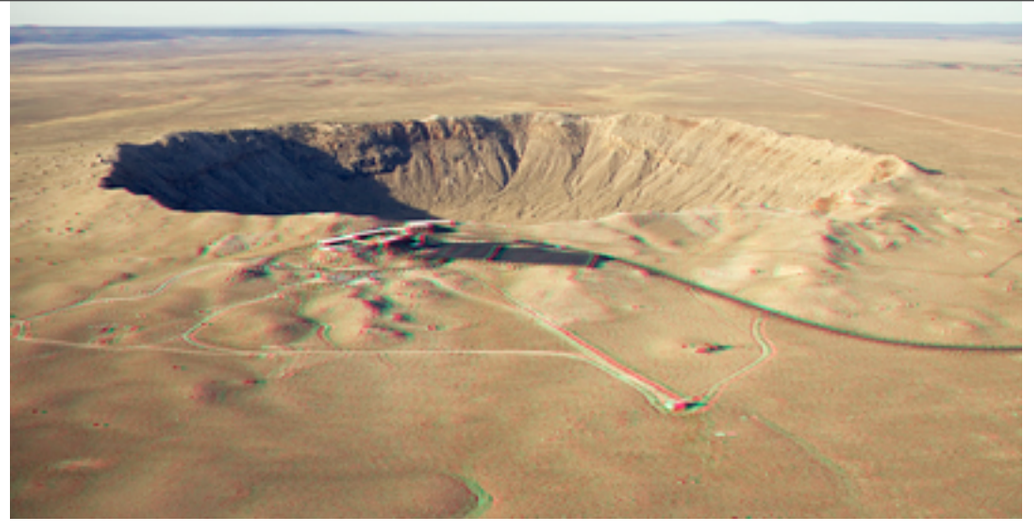
A year later, objects start to lift off from Mars, and they are coming toward Earth!

As they land, there is nothing we can do.

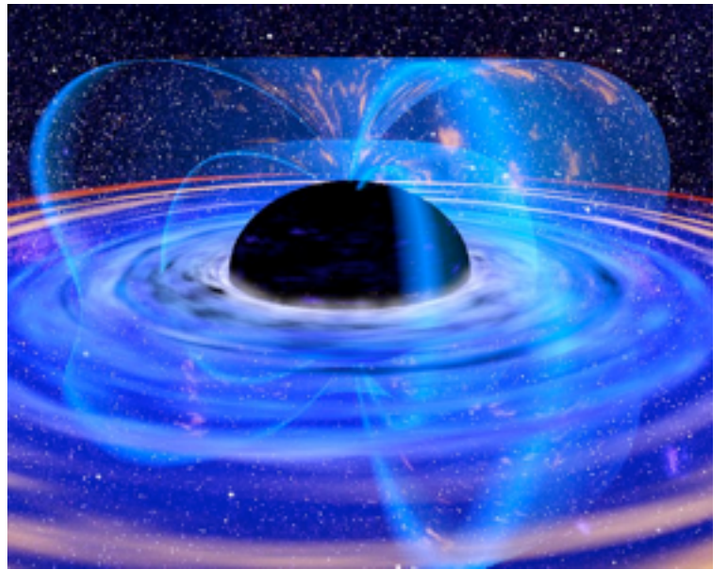
They begin to destroy the surface of the Earth, making more replicates of themselves.

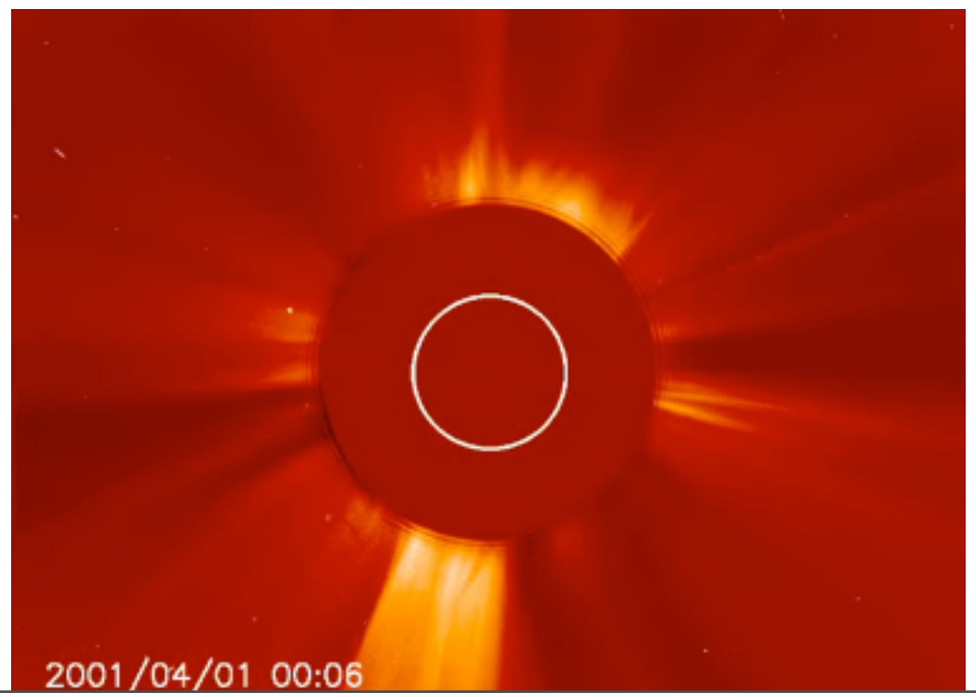
As you are ripped apart for your heavy elements, you wonder why you didn't pay attention during the last few days of Leslie's class.

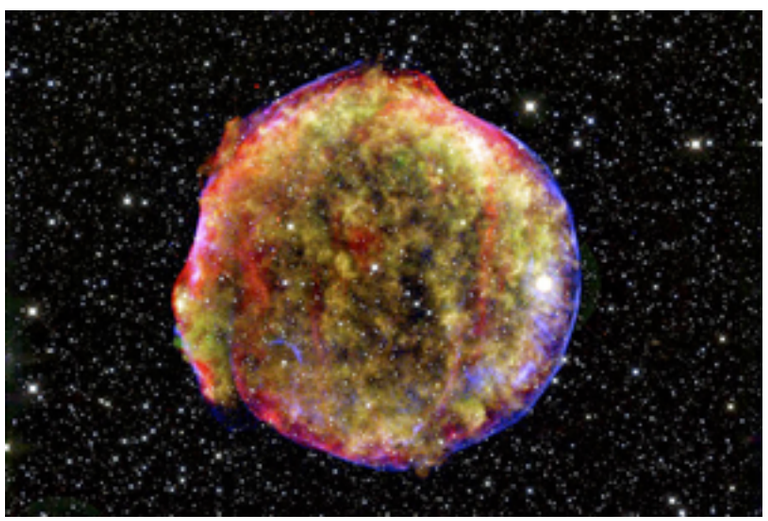




Finale







Putting it all in Perspective:
"The Galaxy Song"
from
The Meaning of Life
Python, M (1983)

From the Home Office in Urbana Illinois

Top 10 Ways Astronomy Can Kill you or your Descendants

10. Alien Attack - Are we alone?

9. The End of Everything - Dark Energy and the Fate of the Universe

8. Galaxy Collisions - Milky Way vs. Andromeda

7. Death by Black Hole - Black Holes don't suck, but if they hit you it sucks

6. Supermassive black hole jets: cosmic blowtorches

From the Home Office in Urbana Illinois

Top 10 Ways Astronomy Can Kill you or your Descendants

5. Death of the Sun - Burn the land and boil the sea

4. Gamma Ray Bursts - Cosmic Death Rays

3. Nearby Supernova - Cosmic WMD?

2. Solar storms - Magnetic bubble, coil, and trouble

1. Impacts! Splat.. Boom… Watch out for space rocks!

The End May be in Sight!

There are real and cosmic hazards to life on earth.

- Some of which are unavoidable

We may have experienced them in the past.

- Could explain lack of evident life in galaxy.

Some of these will happen in the future, and we shall have to leave earth eventually to insure the further existence of humans in our Galaxy.

But for now, everything is fine

is fine...

is fine...

is fine..

is fine....


Thank You &
Good Luck!