Astronomy 150:
Killer Skies

This Class (Lecture 35):
Aliens: Where are They?

Last Class (Lecture 36):
Alien Threats/Review

HW 11 due on Dec 5th

Exam3: Dec 8th

Music: Aliens Exist – *Blink 182*

Exam 3

- Exam 3 in this classroom on Dec 8th, regular time
- 40 Multiple choice questions
- Will cover material from Lecture 26 to last day.
- May bring 1 sheet of paper with notes
  - Both sides
  - Printed/handwritten/whatever.. I don't really care
- Major resources are lecture notes, in-class questions, and homeworks
- Created and posted a new study guide

Online ICES

- Anonymous ICES forms are available online, so far 118/286 (~41%!) students have completed it.
- I **appreciate** you filling them out!
- But, we can do better than 60%!
- **Please** make sure to leave written comments. I find these comments the most useful, and typically that's where I make the most changes to the course.
- This is a newer course, so comments are especially welcomed. Keep in mind constraints of a gen-ed though.

Question

Are you going to fill out an ICES form before the deadline?

a) Yes, I did it already.
b) Yes, sometime today.
c) Yes, I promise to do it before the deadline of Dec 9th!
d) No, I like the class and all, but I am truthfully just to lazy to spend 5 mins filling out an online form. And I have to go zap some zombies or fling some angry birds at pigs.

Question

What was the best part of the computer lab?

a) Playing with real data about asteroids
b) Realizing that it is hard work to find dangerous asteroids
c) Using time-lapsed observations to look for changes in the sky
d) That such an easy assignment was worth 10% of my grade
e) None of the above

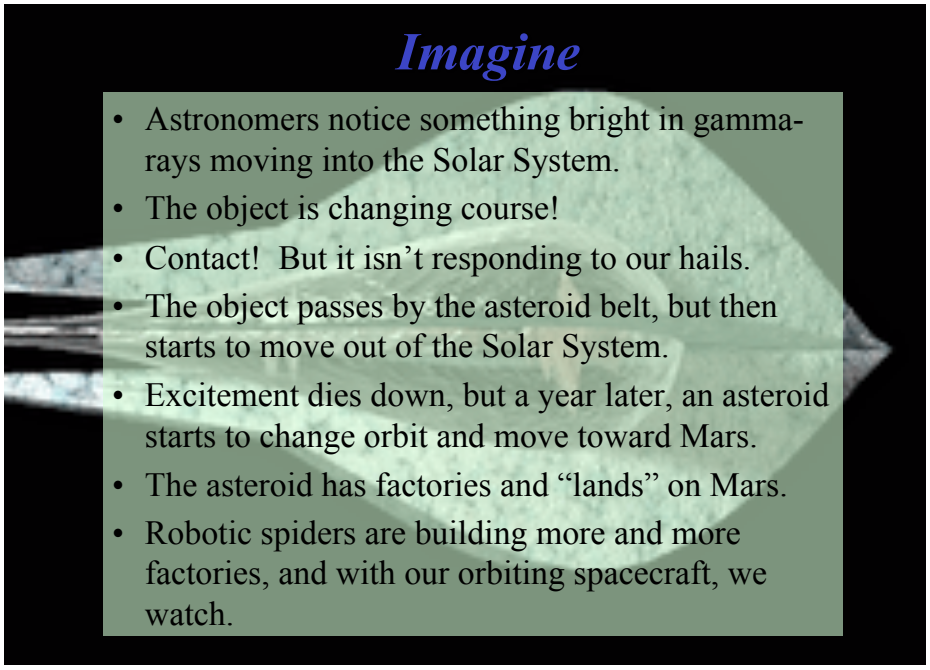
Question

What was the worst part of the computer lab?

a) It was too long
b) It had too much math
c) The instructions were convoluted
d) Boring
e) None of the above

Outline

- What does the Drake Equation tell us?
- Colonizing the Galaxy may not take too much time.
- Where are they?



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.

Are We Alone?

- It's a great time to think about this question!
- In 1995, we knew of 9 planets. Now, in 2010, we know of 500 exoplanets!
  http://planetquest.jpl.nasa.gov/
- 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?***

Questions

Do you think extraterrestrial life exists?

a) Yes
b) No
c) Maybe

Questions

Do you believe that we have been visited by UFOs?

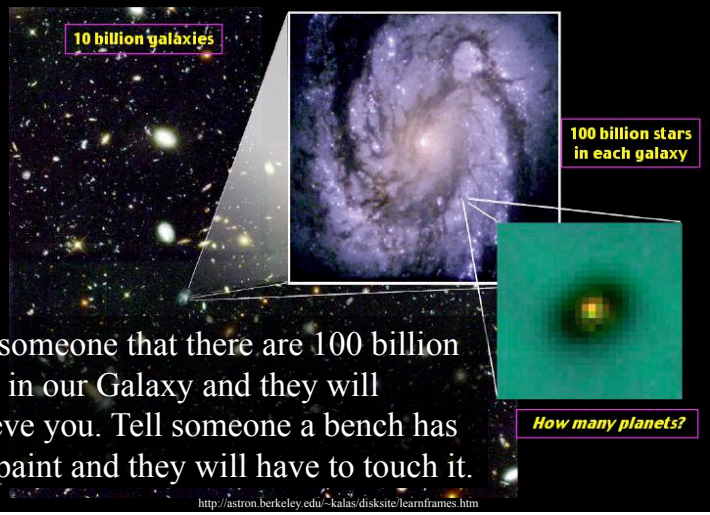
a) Yes
b) No
c) Maybe

Questions

Are UFOs the same as ET life?

a) Yes
b) No
c) Maybe

The Universe: Some Facts to Help you Live in it



Tell someone that there are 100 billion stars in our Galaxy and they will believe you. Tell someone a bench has wet paint and they will have to touch it.

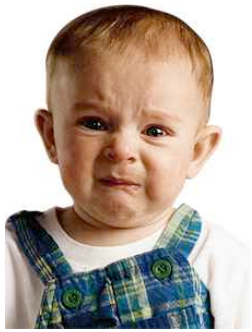
http://astron.berkeley.edu/~kalas/disksite/learnframes.htm

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?

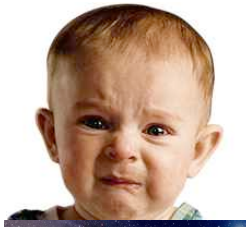
Life?

- Astronomically, we are not special.
- So, we are probably typical in many ways to the other planets around other stars, in other galaxies.
- So, the pre-biotic aspects of Earth is probably typical too.
- One aspect of the study of extraterrestrial intelligent life is to determine if ***life*** is a typical phenomenon.



Life?

- At the very worst, we expect that most galaxies have at least one planet with intelligent life on it
  - As the Milky Way has at least one planet with Intelligent Life.
- So, there ought to be at least 100 billion intelligent civilizations in the Universe!



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

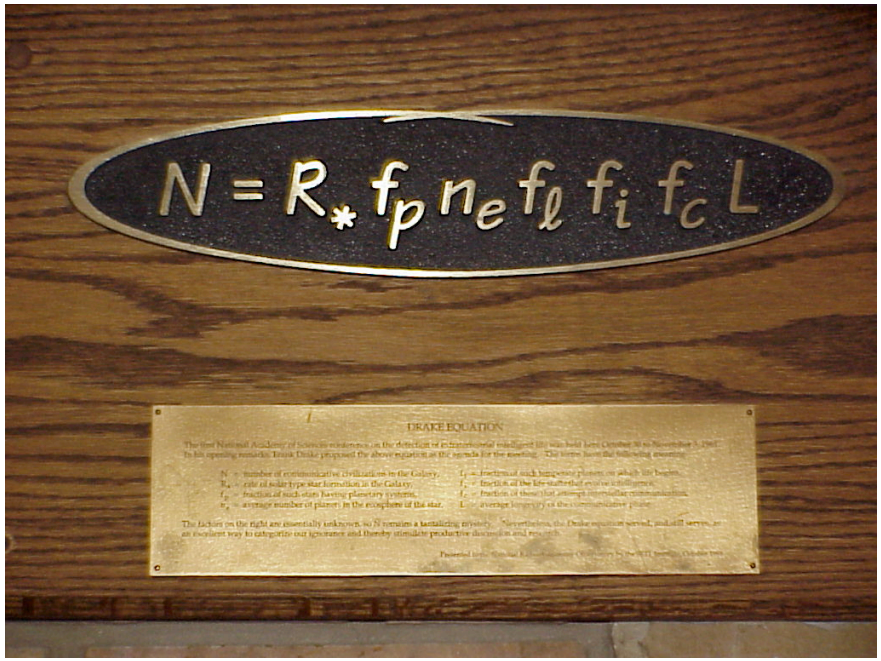
Drake Equation

Frank Drake

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

N	R_*	f_p	n_e	f_l	f_i	f_c	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 communicate	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.

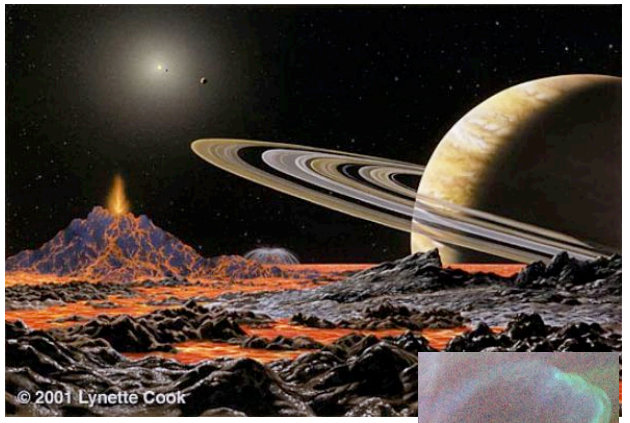


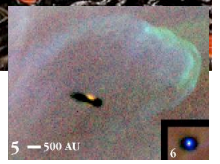
R_*

- 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

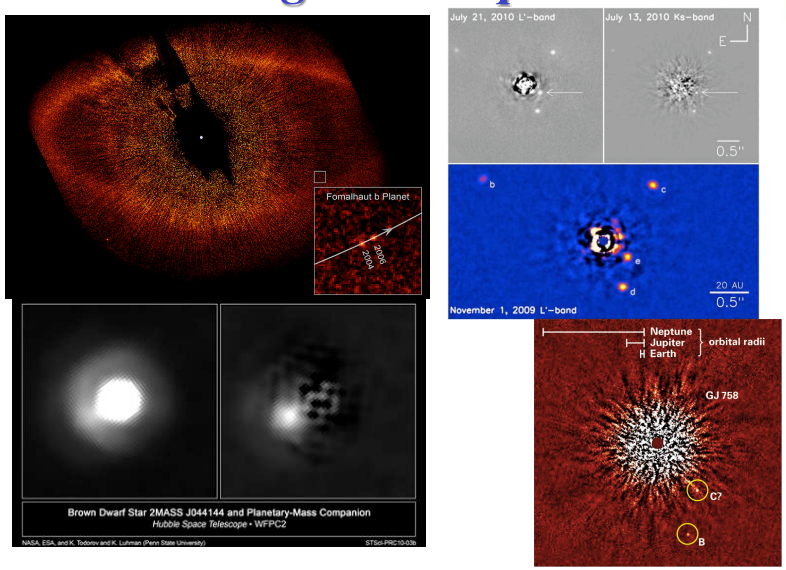
47 Ursae Majoris System– 51 light years away (near the Big Dipper). 13 years of data has shown 2 planets– 1 Jupiter like and 1 Saturn like.





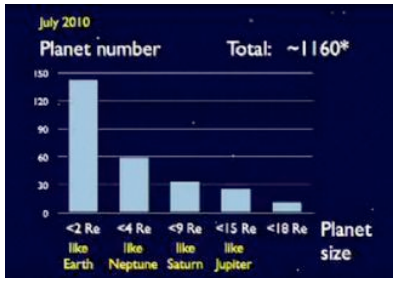
Wow! Among the most similar to our own system

We Imaged 8 Exoplanets!!!!



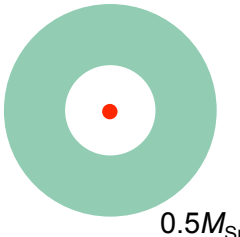
Kepler Mission

- New results from Kepler suggest Earths are more common than we thought.
- Not official press release yet.
- Wait for word soon

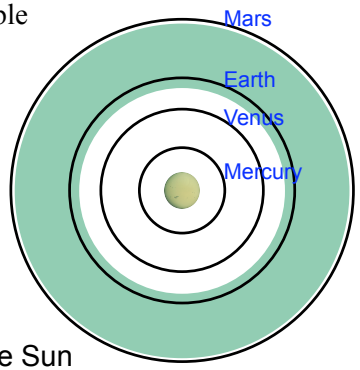


n_e: Habitable Zones– Are you in the Zone?

- Long living star
- Planets with stable orbits (thus stable temps)
- Liquid Water
- Protection from UV radiation



$0.5M_{Sun}$ star



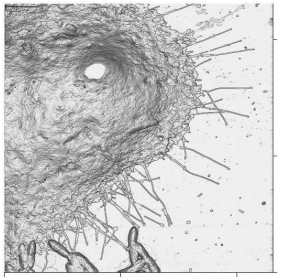
The Sun

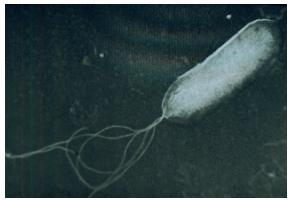
f_l: Cosmic Imperative?

- 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

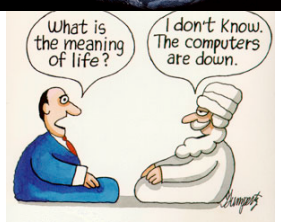




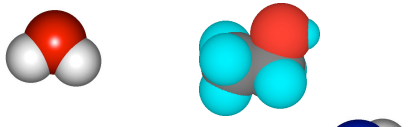
What is the Earth made of?

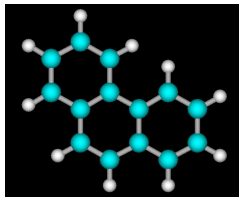
- The makeup of the Earth is very different than our makeup (all life).
- HONC are the elements of life.
  - Hydrogen– Big Bang
  - Oxygen– Fusion of 1st stars
  - Nitrogen– Fusion of 2nd stars
  - Carbon– Fusion of 1st stars
- **"We are star stuff!"**

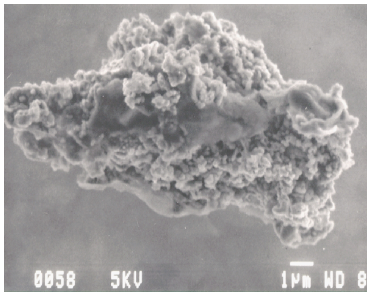



Molecules in Space!

- 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



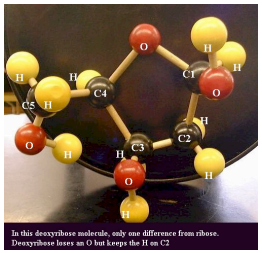

Polycyclic aromatic hydrocarbons (PAH)

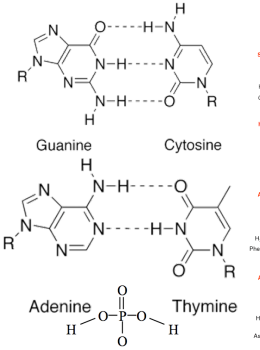


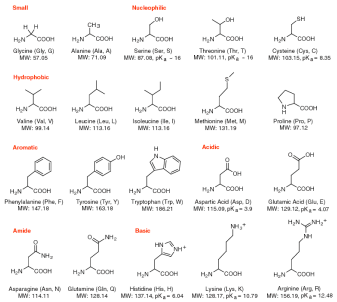
Dust particle (interplanetary)

Life Materials

- Essential life components:
  - DNA: sugar, 4 bases, and phosphorous
  - Proteins: 20 amino acids





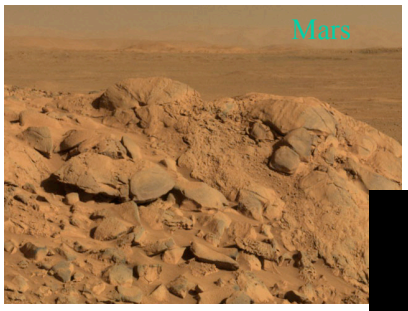


Miller and Urey Experiment

- 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.

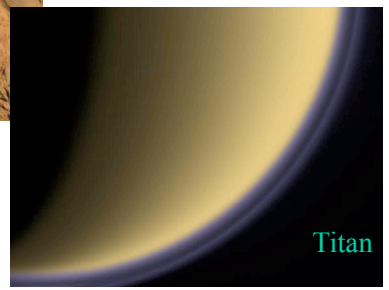
http://physicalsciences.ucsd.edu/news_articles/miller-urey-resurrected051903.htm

Is There Anyone Out There?



Could there be life in a place like this?

Or perhaps a place like this?



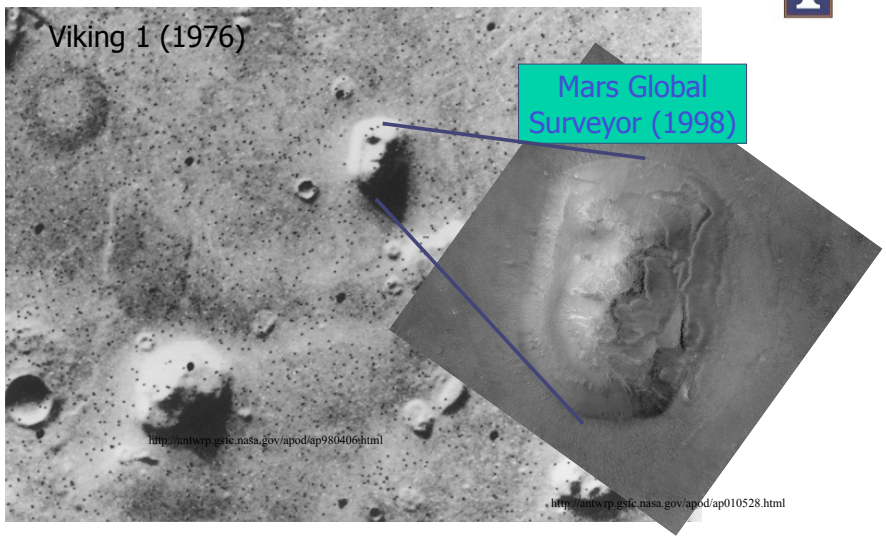
Mars' Past

- Early in Mars' history it was likely more Earth-like
  - Geologically active
  - Volcanic eruptions created a thick carbon dioxide, nitrogen atmosphere
  - Greenhouse effect made it warm enough for liquid water
  - Oceans? Rivers? Glaciers by the poles?
  - Life?

What Happened?

- Mars was too small
  - Not enough internal heat
- Plate tectonics stopped
  - Volcanoes sat over "hotspots" grew to immense sizes
- Volcanic activity slowed as the interior cooled
- The atmosphere escaped
- The planet froze
- Did life move underground?

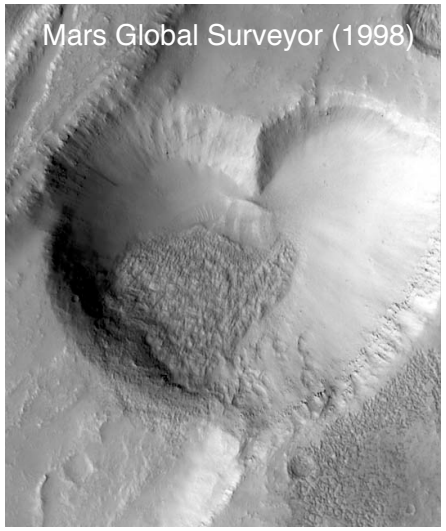
The "Face" of Mars?



Other Faces

http://antwrp.gsfc.nasa.gov/apod/ap990315.html

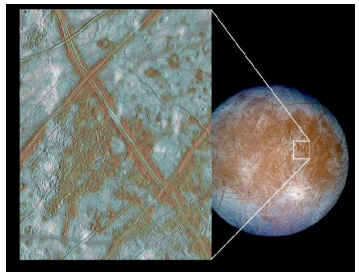
Other Places

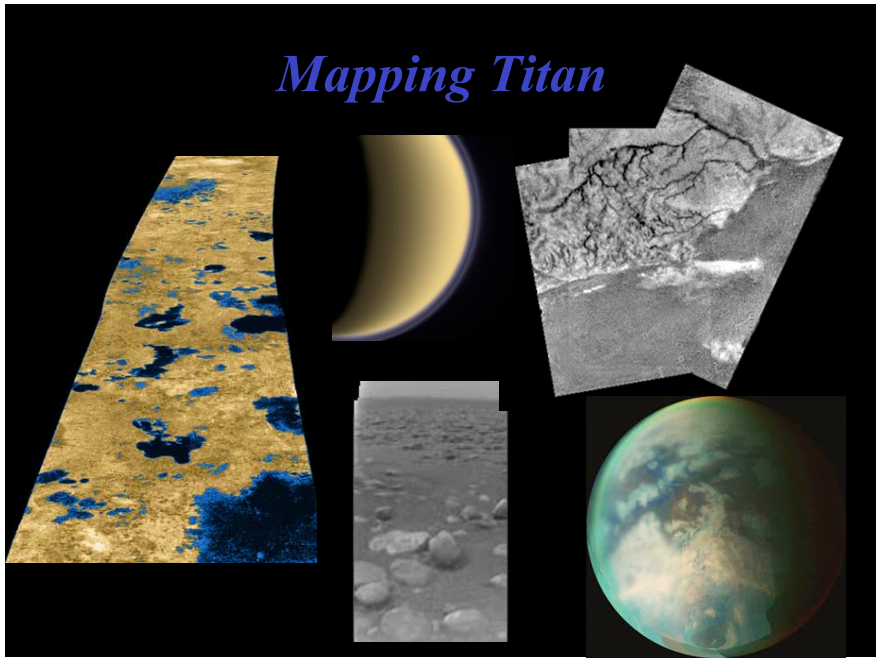


http://www.solarviews.com/cap/mgs/heart.htm

Europa: Moon of Jupiter

- Life would have to be below the surface, around hydrothermal vents.
- Similar to the first Earth life?
- We don't how thick the ice is yet. To be continued.
- Future missions, will have to employ melting or smash and dive spacecraft.



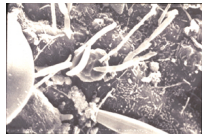


Life in the Solar System

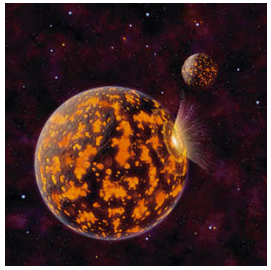
- ***No conclusive evidence exists for life in our solar system besides on Earth***
- But, possibilities exist for life
  - Venus may have microbial life high in the atmosphere, fleeing the high temperature of the surface.
  - Mars may have some microbial history linked to water, and perhaps some subsurface life.
    - Maybe Martian life seeded Earth?
  - Europa's sub-crustal oceans may harbor life, even fish-like life.
  - Titan is very interesting
    - Thick atmosphere

How Old is Life?

- Earth's early geologic record (first 1/2 billion years) is GONE
  - Clues to early life formation are gone



- But, we do have evidence for very early microbial life on Earth (about 4 billion yrs old).
- The heavy bombardment ended at about that time.
- First multi-celled life about 1 billion years ago



Chain of Life on Earth

- 3.5 Byrs ago: **Bombardment of Earth stopped.**
- 3.8 Byrs ago: **First known fossils**

Making Oxygen: The First Air Pollution

- The early Earth had no oxygen.
- Cyanobacteria changed the world!
- Created first environmental disaster!
- Oxygen rich atmosphere about 2 Byrs ago, allowing more complicated life.
  - Like you

Chain of Life on Earth

- 3.5 Byrs ago: **Bombardment of Earth stopped.**
- 3.8 Byrs ago: **First known fossils**
- 1 Byrs ago: **First multi-celled organisms.**
- 500 Myrs ago: **First boned creature– first fish.**
- 400 Myrs ago: **First amphibians.**
- 300 Myrs ago: **Many animals.**
- 200 Myrs ago: **Dinosaurs.**
- 100 Myrs ago: **Birds, mammals, flowering plants.**
- 65 Myrs ago: **Mass extinction– new chance for mammals.**
- 5 Myrs ago: **First humanoids.**

Life

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?

A) Animals

B) Small stuff

Life

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?

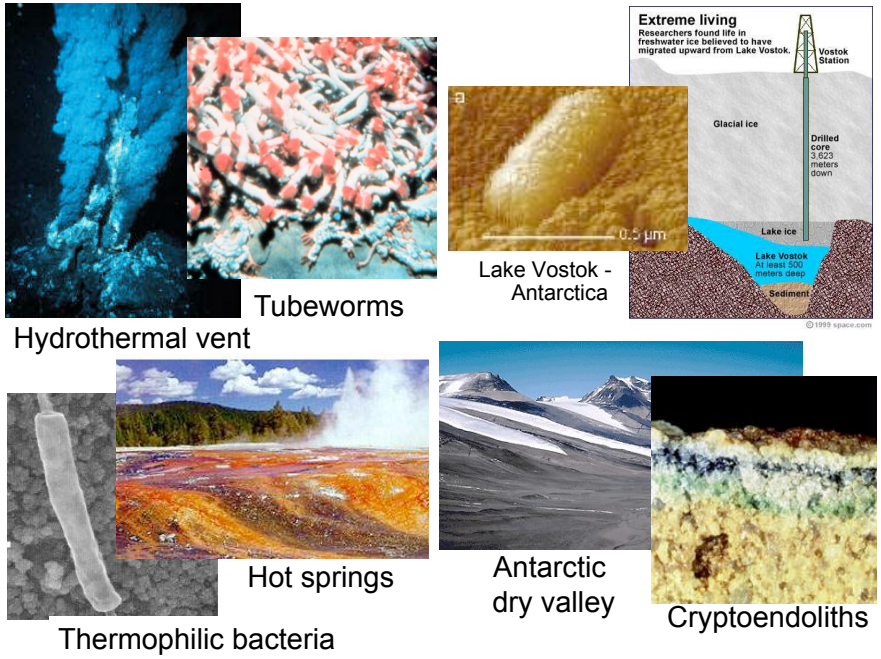
Around 90% of all biomass on the Earth is in the smallest and simplest lifeforms.

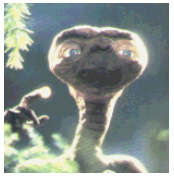
You or not you?

- This are more non-you cells in your body than you-cells in your body!
  - You are outnumbered 10 to 1!
  - Mostly on your skin and in your digestive track

Bacteria under a toe-nail

http://news.nationalgeographic.com/news/2007/02/070206-skin-microbes.html



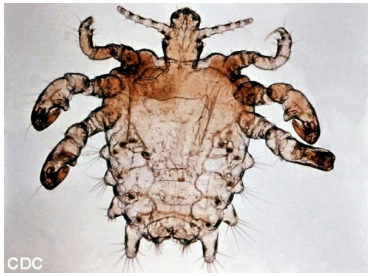


Not your Parent's ET-- Extremophiles

- These are microbes that live 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, as they are the most likely candidate for extraterrestrial life.
- Probably dominated life on early Earth until ***fairly recently***.

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 pubic hair lice! Also called crabs.

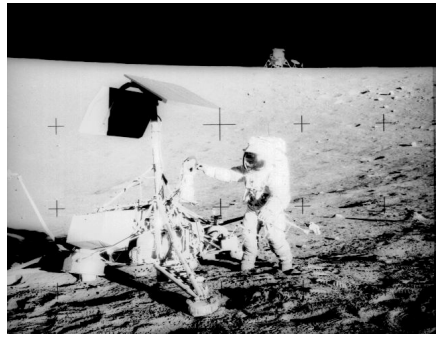
Panspermia

- Some have stated that perhaps life-important molecules formed in molecular clouds and spread to planets. **Infection!**
- Comets could have carried molecules to Earth's surface. Or ordinary meteors.
- Or some even claim that simple life came from the stars!

http://www.daviddarling.info/images/lithopanspermia.jpg

Panspermia: Case in Point

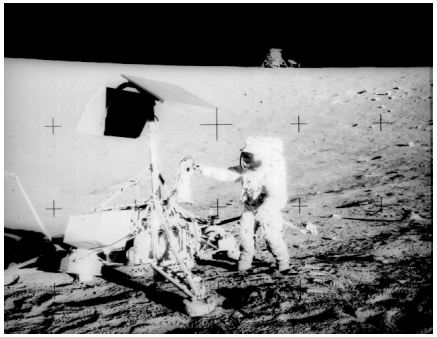
- Surveyor 3: unmanned lunar probe which landed in 1967.
- 2.5 years later, a camera was retrieved by Apollo astronauts.
- The camera had 50 to 100 viable specimens of *Streptococcus mitis*, a harmless bacterium commonly found in the human nose, mouth, and throat.



http://nssdc.gsfc.nasa.gov/planetary/news/image/conrad_19990709_c.jpg

Panspermia: Case in Point

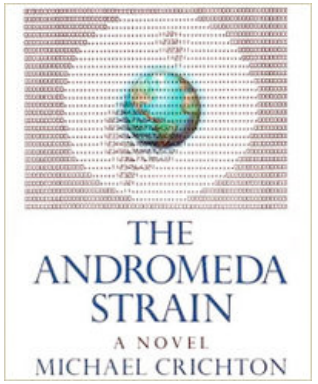
- The camera was returned under strict sterile conditions.
- The bacteria had survived 31 months in the absence of air or water!
- In SPACE!
- Was subjected to large monthly temperature variations and hard ultraviolet radiation from the Sun.



http://nssdc.gsfc.nasa.gov/planetary/news/image/conrad_19990709_c.jpg

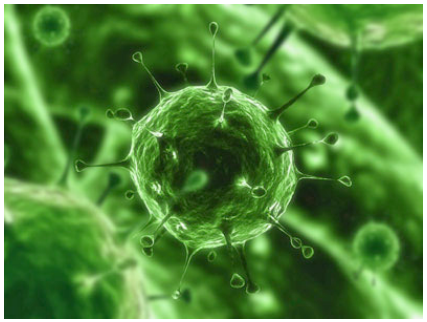
Panspermia: Alien Invaders

- If life on Earth came from Panspermia, what if "they" come back?
- Virus or bacteria inside a rock, could survive space travel and Earth landing.
- But, interstellar travel for micro-life is very, very unlikely.
- But even still, could they hurt us?



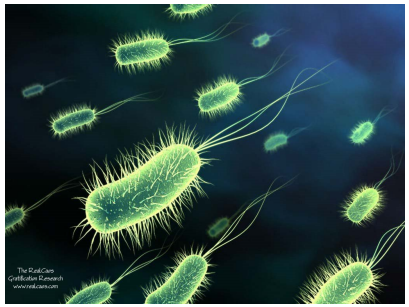
Alien Invaders: Viruses

- Viruses are simple; space travel would be easiest for them.
- Although simple, they are very specialized.
- A plant virus can not infect an insect.
- Too simple to change on quick timescales.
- So, likely can not hurt us.



Alien Invaders: Bacteria

- Bacteria are more complex.
- Able to survive in more "hosts"– worst guest ever!
- You already host many colonies on your skin and inside your body!
- But, remember fine-tuned: we evolved together: regular and extremes.
- Alien life would likely be killed off before major damage.



Question

If an alien bacteria or virus lands on Earth it is unlikely to be seriously dangerous to humans why?

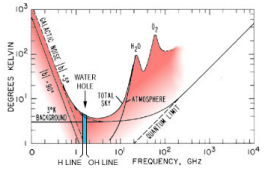
a) No hands. No ray guns.
b) Terrestrial bacteria or viruses have evolved to become dangerous to humans.
c) They are too little to make any difference.
d) It is totally impossible for alien bacteria or viruses to land on Earth.
e) The Drake Equation proves that ET life can not exist.

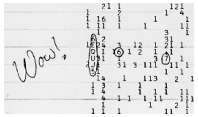
f_i: Intelligence

- 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.
- SETI problems
  - Where to look
  - What freq to look
  - What code to use
  - Etc…





L: Lifetime

What is L?

How long on **average** can an advanced civilization exist?

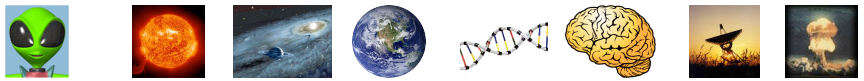
- Short Term (100-1000 yrs)
  - Give up on communication due to budgets.
  - Depletion of resources.
  - Population.
  - War.
- Long Term (100,000 to 5 Byrs– age of galaxy is ~13 Byrs yrs and we took nearly half of that to evolve)
  - Stellar Evolution.
- Don't forget the random volcano, asteroid, or supernova.
- Still in many cases an advanced civilization may be prepared for many of the issues!

Drake Equation For Optimist

= 2.5 x 10^{11}

Communicating Civilizations

62.5% of all stars in our Galaxy.



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

N	R_*	f_p	n_e	f_l	f_i	f_c	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 x 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!