Top Ten Signs
Your Astronomy Professor May Be Nuts
(based on Lee Carkner List)

10) The title of every lecture is: "Man, Them Stars is Hot!".
9) His so-called "telescopes" are really just paper towel rolls covered in aluminum foil.
8) To illustrate the vastness of the universe, he makes everybody walk to Springfield.
7) Thinks he's married to the slide remote.
6) Your grade is based entirely on how many ping-pong balls you can fit in your mouth.
5) His so-called Drake Equation video is really just an old episode of Alf.
4) He makes everyone wear a soup pot on their head to protect the class from "Klingon mind control lasers".
3) About 90% of all classes involve dressing monkeys up to look like Frank Drake.
2) When you go to his office hours, he is always hiding under the desk so that the "space squirrels" can't get him.
1) The only observing advice he ever gives is, "Keep an eye out for the mothership."

Astronomy 150:
Killer Skies

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

HW 11 due on Dec 10th

Final: Dec 15th,
1:30pm-4:30pm in classroom

Music: Aliens Exist – *Blink 182*

Final

- In this classroom Dec15th, 1330-1630 (1:30pm-4:30pm).
- Will consist of
  - 18 question on Exam 1 material.
  - 18 question on Exam 2 material.
  - 35 questions from new material (Lect 23+).
  - +4 extra credit questions
- A total of 210 points graded out of 200 points, i.e. 5 points of extra credit.
- A normal-sized sheet of paper with notes on both sides is allowed.
- Exam 1and 2 are posted on class website (not Compass).
- I will post a review sheet

Final

- If you have a conflict, we will have a conflict exam on Thursday 1330-1630 (1:30pm-4:30pm), in the astronomy building, room 238.
- You MUST email me to pre-approve any conflict.
  - If this is for a combined final exam, UIUC policy is that you must do a conflict exam for that course.

Grades

- I will endeavor to post grades for each topic as soon as I can. Check compass regularly.
- Remember, I will drop 6 of the participation credits (plus 1 extra credit), AND 1 of the HWs.
- Running a little behind on the Night Labs and Asteroid Lab, 80% done.
- Nonetheless, medians of those are 100%, so most people doing quite well.
- If you want your papers back, set up an appointment to see me.

Question

Do you take an intro astronomy course (e.g. Astro 100, 121/122, or 210)?

a) Yes.
b) No.

Question

Do you think I should not allow students with an intro astronomy course (e.g. Astro100,121/122, or 210) to register for this course?

a) Yes, I took one of these classes and there was too much overlap.
b) Yes. I didn't take one, and I felt those that did had an unfair advantage.
c) No, I took one and this class, although sometime covering similar material, does it in a very unique way.

Online ICES

- Anonymous ICES forms are available online, so far 154/244 (~63%!) students have completed it.
- I **appreciate** you filling them out!
- **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 new 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 10th!
d) No, I have too much else to do, so I can't help you out. My facebook page is so out of date that my friends don't know what movie I saw last weekend!

Outline

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

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.

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?

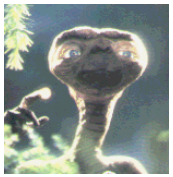
Around 90% of all biomass on the Earth is in the smallest and simplest lifeforms.

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

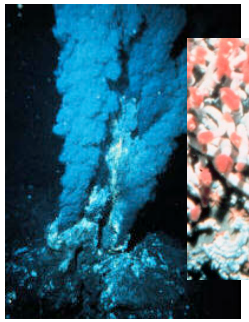
Bacteria under a toe-nail

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



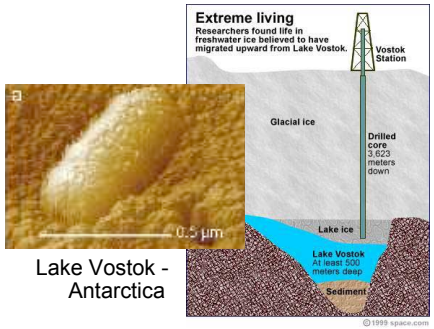
Not your Parent's ET-- Extremophiles

- 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***.

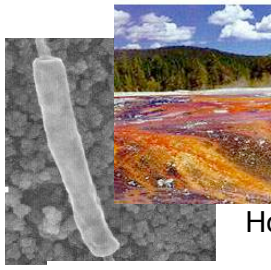


Hydrothermal vent

Tubeworms

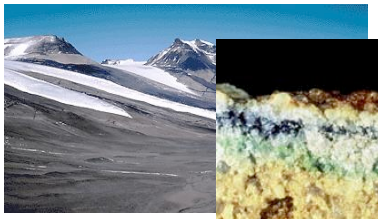


Lake Vostok - Antarctica



Thermophilic bacteria

Hot springs

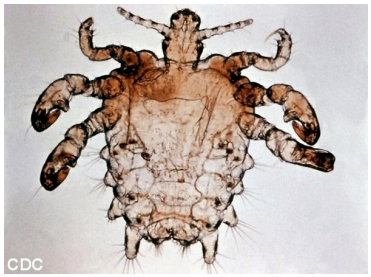


Antarctic dry valley

Cryptoendoliths

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.

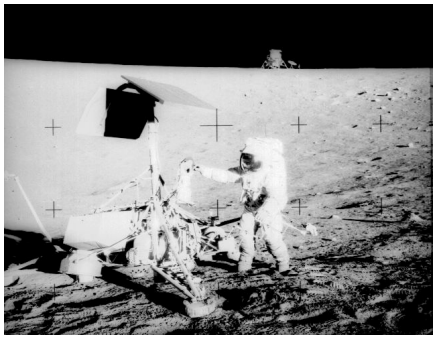
Panspermia

- 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

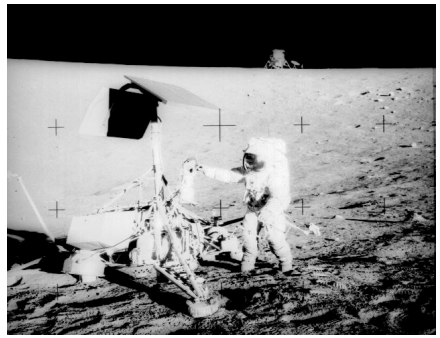
- Surveyor 3: unmanned lunar probe which landed in 1967.
- 2.5 years later, a camera was retrieved by Apollo astronauts.
- The camera had 50 to 100 viable specimens of *Streptococcus mitis*, a harmless bacterium commonly found in the human nose, mouth, and throat.



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

Panspermia: Case in Point

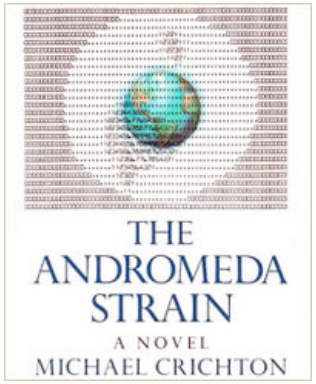
- The camera was returned under strict sterile conditions.
- The bacteria had survived 31 months in the absence of air or water!
- In SPACE!
- Was subjected to large monthly temperature variations and hard ultraviolet radiation from the Sun.



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

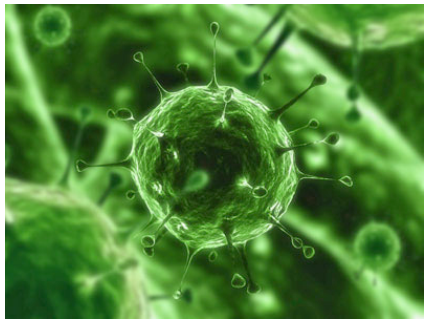
Panspermia: Alien Invaders

- 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?



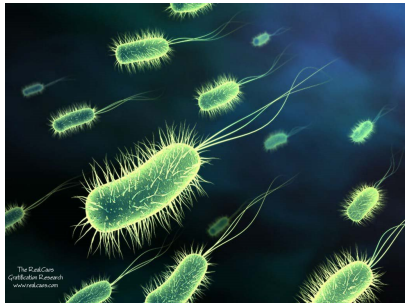
Alien Invaders: Viruses

- 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?

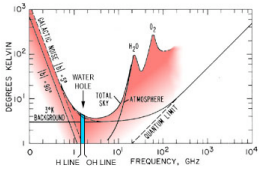
a) No hands. No ray guns.
b) Terrestrial bacteria or viruses have evolved to become dangerous to humans.
c) They are too little to make an difference.
d) It is totally impossible for alien bacteria or viruses to land on Earth.
e) The Drake Equation proves that ET life can not exist.

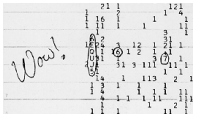
f_i: Intelligence

- 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.

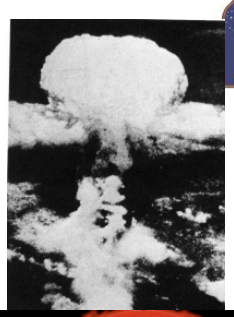
f_c : Galactically Aware

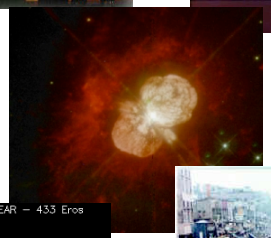
- Realization that extraterrestrial life is possible.
- The urge and technology to communicate.
- SETI problems
  - Where to look
  - What freq to look
  - What code to use
  - Etc…

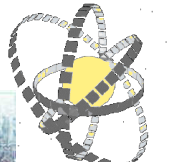




L: Lifetime







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.

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

# 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 x 10^{-8} / year!

Drake Equation For Average

= 930,000

Communicating Civilizations

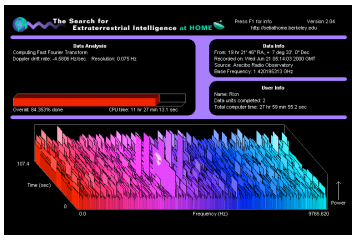
$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

# 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	1x10^6

Birthrate of 0.93 /year!

How to Communicate?

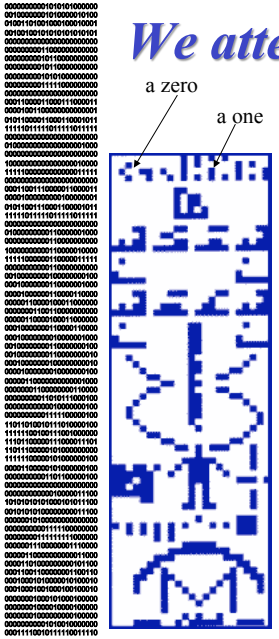
- If there, how do we go about detecting our neighbors?
- Are we seriously sending out messages now?
- No.
- We are relatively a young civilization, with radio technology for only a hundred years.
- Right now, we are mostly a passive “lurker” civilization.



Allen Telescope Array

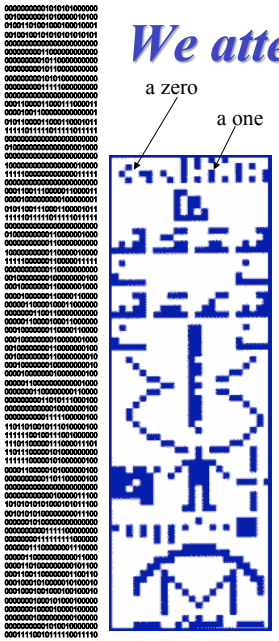
- UC Berkeley and the SETI Institute with majority of funding from Paul Allen are building the ATA.
- 350 antennas– each 6.1 m in diameter.
- With advanced electronics it will cover 1-10 GHz with many channels.
- Can image a few stars per field.
- 100% SETI time
- Will increase search to 100,000 or 1 Million stars.

We attempted Contact



- The first real signal sent was in 1974 by the Arecibo telescope (20 trillion Watts of power).
- Sent toward the globular cluster M13 which is 21,000 lyrs away.
- Now, we wait.

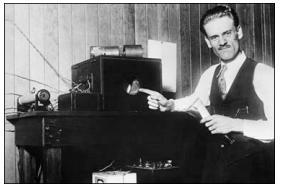
We attempted Contact



- ET should be able to arrange data into a picture.
- If they're looking, a SETI experiment will detect this.
- A few signals recently by companies, but arguably not taken seriously.

Does ET Love Lucy?

- Another possibility is to look for unintentional leakage signals.
- Leakage, as it "leaks" from the planet's ionosphere.
- We can not currently detect this, but maybe other civilizations can.
- What leakage do we have? TV, FM Radio, radar



http://www.time.com/time/time100/scientist/profile/farnsworth.html

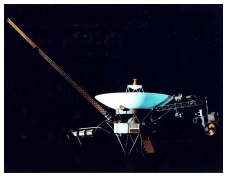
Contact

"If humans were the only life in the Universe it would be a terrible waste of space."

Vega calls us back, but how can we be sure that we're listening?

Our leakage radiation is actually decreasing with cable, fiber optics, direct satellite, etc. Civilizations may not spend much time in that phase.

Interstellar Travel

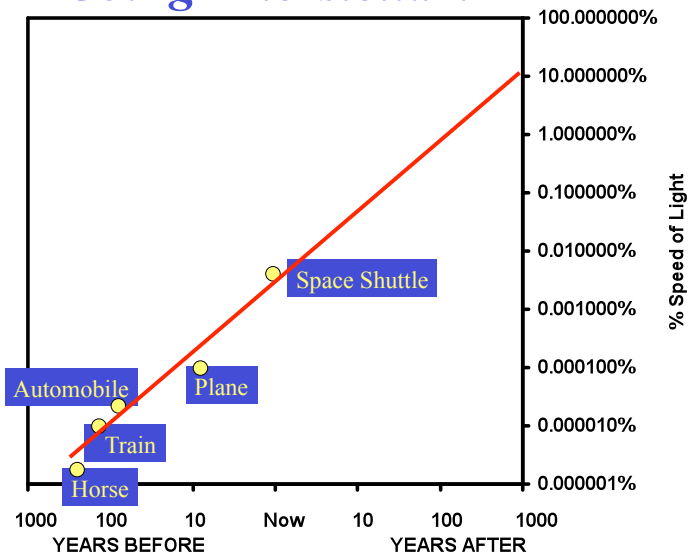


- But, what if all communication with ET fails?
  - Wrong frequencies.
  - Everyone is listening and no one is broadcasting.
  - We fail to recognize the signal.
- We can go visit them or the microbes. "To boldly go…"
- BUT, the distances are huge!
- Nearest star is 4.3 ly away or around 4 x 10^{13} km!
- **40,000,000,000,000 km! 40 TRILLION km!!!**
- Our fastest object, Voyager would take nearly 100,000 years

Problems to Overcome?

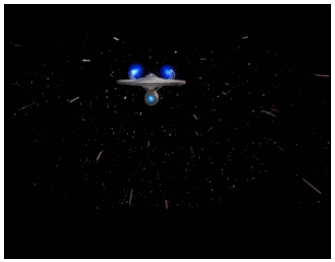
1. Space is Big.
   - Nothing we can probably do about this one.
2. Time.
   - Because of #1, interstellar travel would take a lot of time.
   - But arguably do-able.
     - Maybe lifetime is expanded, generation ships, suspended animation, or intelligent robots.
3. Cost
   - Right now, colossal budget 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.

Going Interstellar!



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

The future:

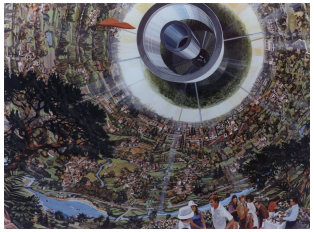
May bring us closer to the speed of light

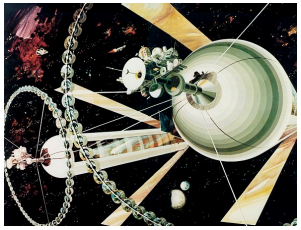
- Right now we can travel through space at about c/25,000
- Maybe fusion-powered crafts could in the near future reach 0.01c or maybe even 0.10c

http://www.jedisaber.com/SW/wallpaper/light%20speed.jpg

1000 Years?

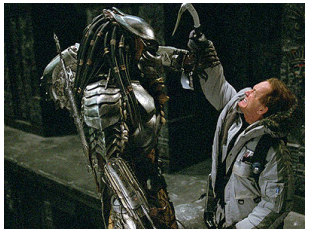
- So in 1000 years from now, we should be able to travel to other stars. But will we?
- It would be nuts to speculate on what will motivate our descendents (if any) 1000 years from now. But if interstellar travel really is easy and cheap, surely someone will give it a go?

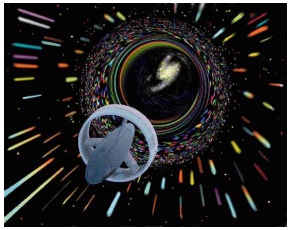


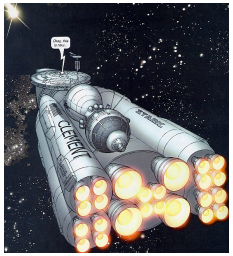


Getting Out of Here

- 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





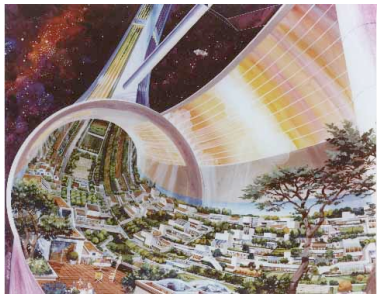


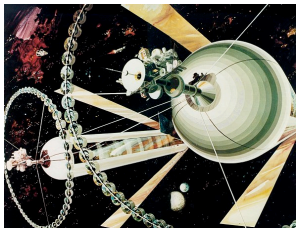
Galaxy Colonization

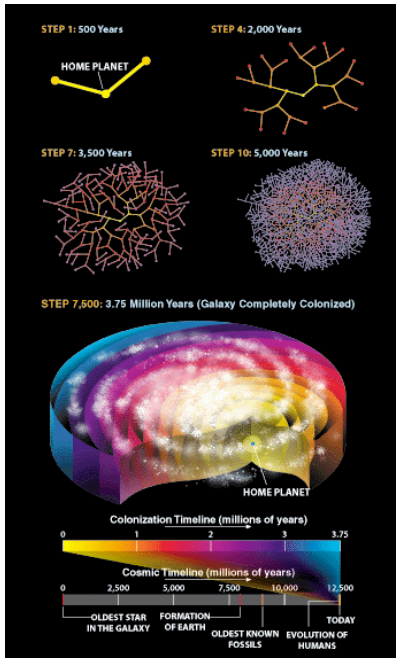
- If the average Drake equation estimate is roughly right, there could be civilizations that are 1 billion years old!
- Think of the accomplishments.
- Even if interstellar travel is limited to 0.1c, civilizations with advanced telescopes could send colonizing craft to new "Earth-like" planets.

How long to colonize the Galaxy?

- With 0.1c, we can travel 10 light years in 100 years
- Can reach the nearest star in 43 years
- How long to colonize the Galaxy?







Optimistic

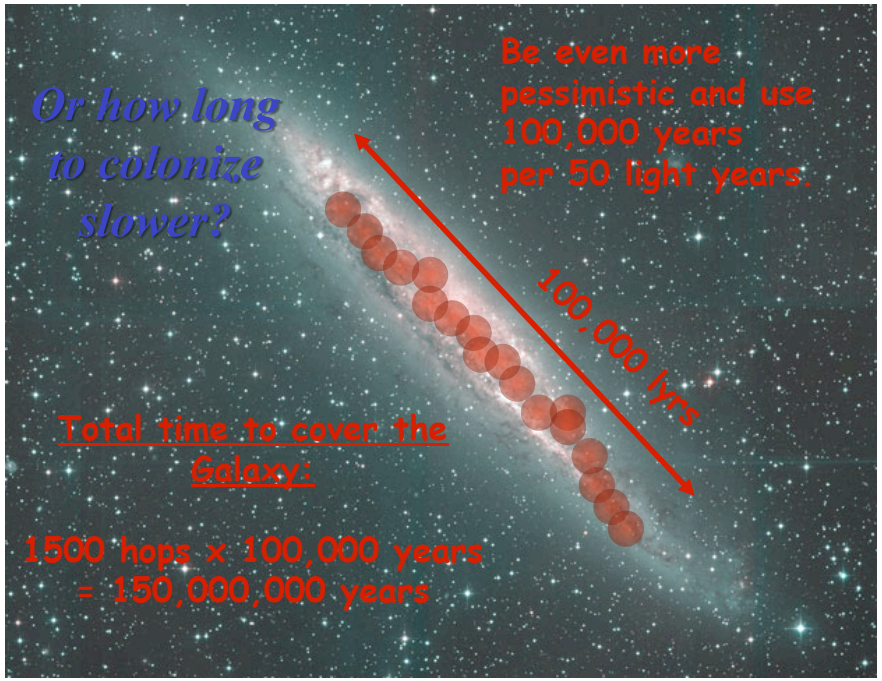
Every 500 years, the colonization craft makes it to the next suitable solar system– small delay.

Colonization only takes about 4 million years!

Slow Long Haul Space Travel

- Spacecraft that we can envision easily would take a lifetime to get to the nearest star.
- Colonizing missions would have to be multi-generation missions.
- Space colonies with propulsion systems would slow down things, so maybe it would take 1000 yrs or more for each trip.
- How many of you would sign up today?

A) Yes B) No



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.

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 .

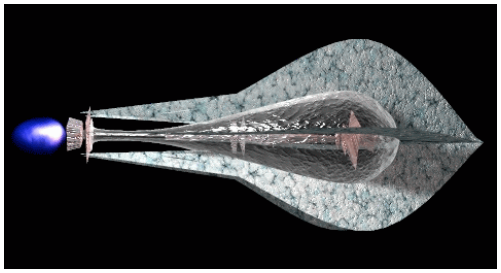
Neumann Space Probed

- 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

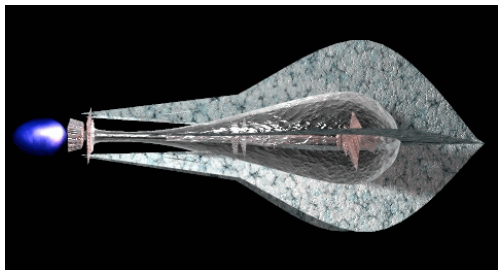
Neumann Space Probed

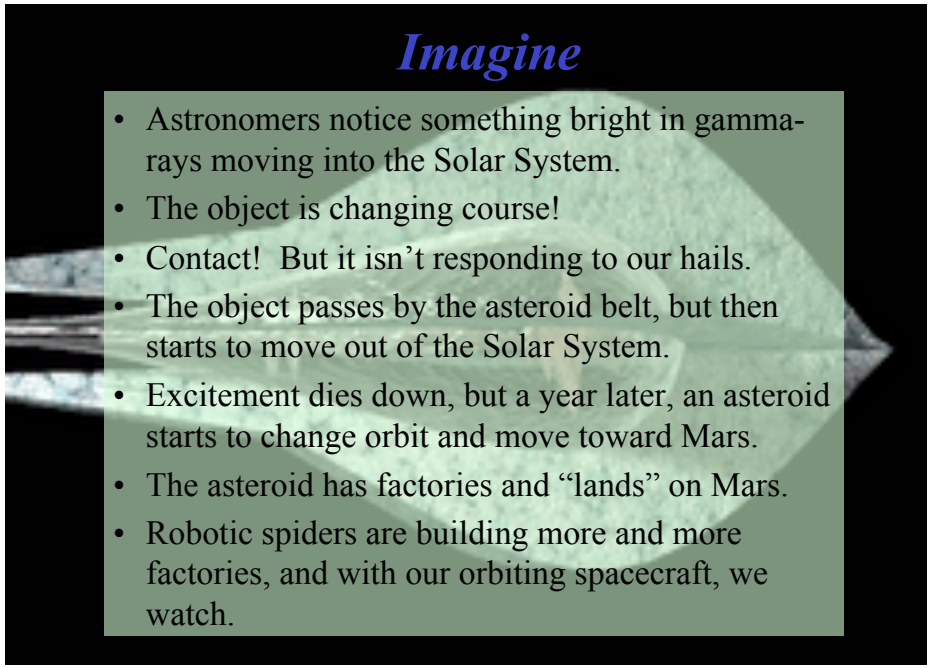
- What if it’s armchair generals instead of explorers.
- Decide to change the galaxy by force?
- What if programming goes crazy, and the objects decide to ignore the explore part and focus on only the replicate part?
- Might be a larger possibility than we thought.

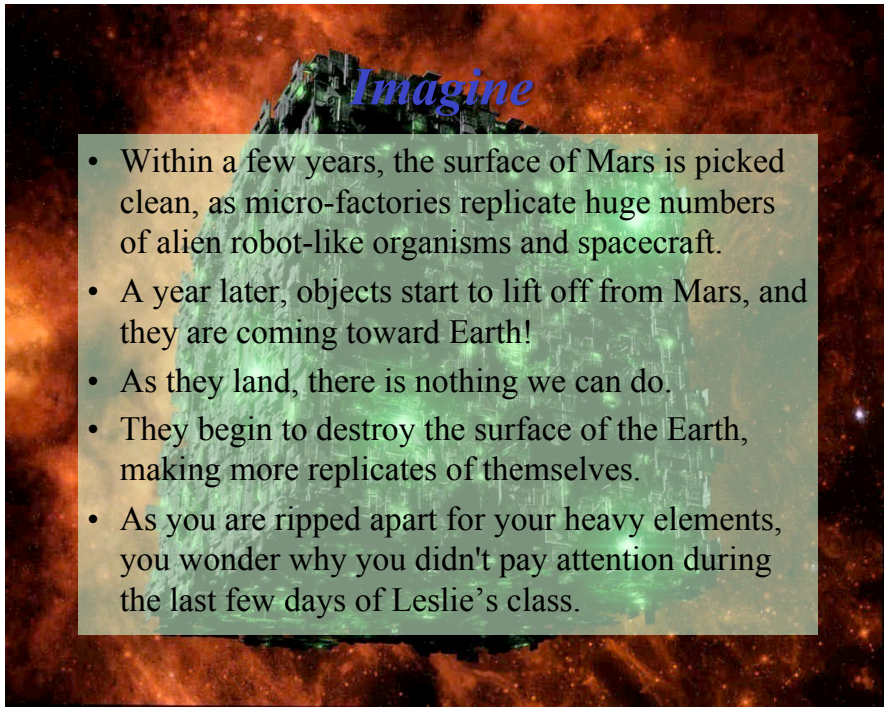


Mitigation

- 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!







Top 10 Ways Astronomy Can Kill you or your Descendents

1. Impacts!
   Splat.. Boom… Watch out for space rocks!
2. Solar Evolution.
   MS to Red Giant to White Dwarf.
3. Coronal Mass Ejections
   Cold winter days..
4. Supernova in your face!
   Super sunburn.
5. Gamma Ray Burst.
   From anywhere…

Top 10 Ways Astronomy Can Kill you or your Descendents

6. Rogue compact objects–White Dwarfs/Black Holes.
   Black Holes don't suck, but if they hit you it sucks.
7. Galaxy Collisions.
   Milky Way vs. Andromeda.
8. Cosmology!
   This is the way the Universe ends..
9. Quasars. The Monster in the Milky Way?
   It burnssss…
10. Aliens.
    You're kidding right…

The End May be in Sight!

- There are cosmic hazards to life on earth.
- We may have experienced them in the past.
- Could explain lack of evident life in galaxy.
- Some of these WILL happen, 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….