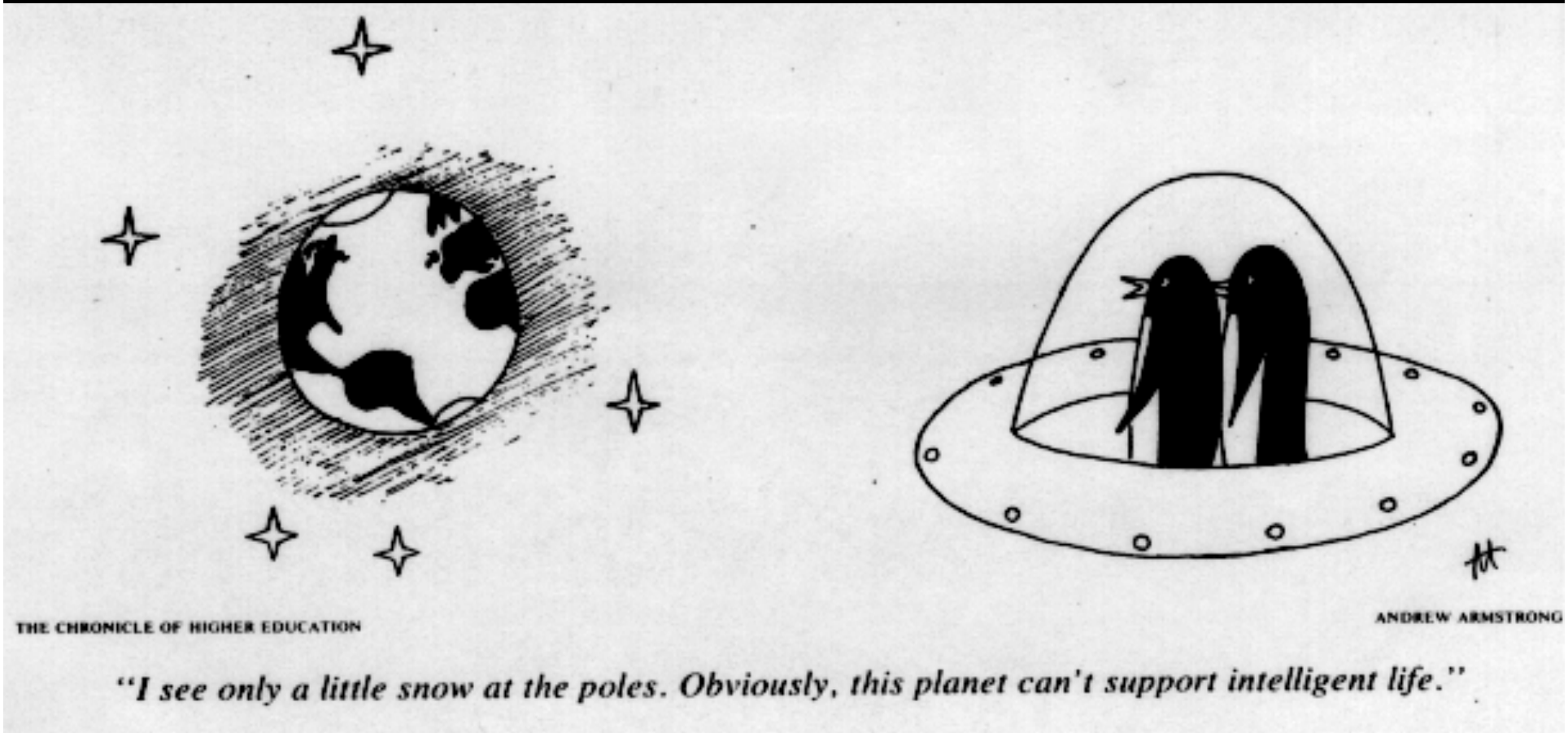
ASTR 380
The Fermi Paradox



"I see only a little snow at the poles. Obviously, this planet can't support intelligent life."

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If we are not unique in developing a technological society in the galaxy….. Where is everyone else?

The simple statement of the Fermi Paradox is:

- Planets are common
- Earth–like planets are likely to be common
- Life is likely on them
- Intelligence is a natural adaptation
- Many civilizations should exist….

Where are they?

Paradox is named after Enrico Fermi – a famous physicist.

Let's explore this in some more detail

Reminder

- Course evaluations now open
- Go to www.CourseEvalUM.umd.edu
- Can fill out through December 14
- Please do fill in; even if you don't like this course, I'd appreciate knowing why!

Announcement

- Last day of class, Thurs, Dec 11
- Will be course review
- I will go over 10 major points in class, then the rest will be entirely driven by your questions
- As before, no variant of "what will be on the exam?" will be answered
- Answer: final is cumulative (i.e., everything in course), more focus on material after midterm
- Format of final is same as midterm, homeworks

Colonization of Milky Way

- Our galaxy is 100,000 light years across
- Right now we can travel nearly 30 km/s, or 1/10,000 of speed of light
- Thus takes only 10,000x100,000=1 billion years to go across galaxy
  But Milky Way is >10 billion years old
- Therefore, plenty of time!

Problems With Argument?

- Can't reach every star in a straight line!
- Santa Claus problem: circling Earth is okay in a night, but not visiting every house
- Total interstellar distance is >trillion light years
- Have we solved the Fermi Paradox?

http://flashyourstache.files.wordpress.com/2007/12/santa_claus.jpg

Strategy for Colonization

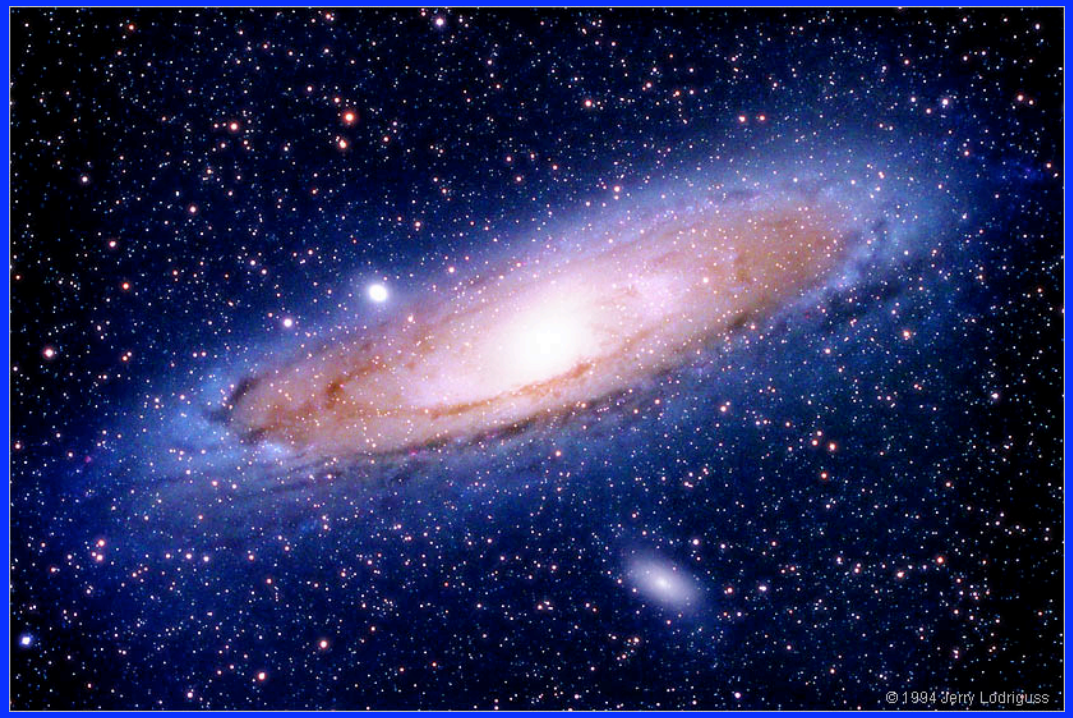
- No, that “disproof” doesn’t work
- Start out with one planet
- Send exploration to two planets
- Those two send to two each, for four
- Next round: 8, then 16, 32, ...
- Exponential growth accesses galaxy easily
- Time really is limited by galaxy diameter

What About Heavy Elements?

- Perhaps a certain fraction of heavy elements is crucial for planets with life
- We happen to be in the first wave, so we do not expect more advanced life
- However, towards our galactic center heavy elements developed earlier
- Also, a billion years here or there is nothing!

Multi-Galaxy Civilizations?

- Galaxy distances are huge
- Nearest big one: Andromeda, 2.2 million lyr away
- Take 22 billion years at 1/10,000 speed of light
- To span galaxies, need major propulsion advance!



Getting Around Fermi

- In our galaxy, at least, colonization is simple in principle given the amount of time we have had
- But the aliens aren't here
- What are possible explanations?

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Possible Conclusion #1: We are unique in the Universe.

WHY?

We are a one in a billion accident – then why do we exist?

We are a one in a trillion accident. We live in one of the universes where intelligent beings exist.

We exist in this Universe because it is perfectly suited to support our existence.

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Possible Conclusion #1: We are unique in the Universe.

Note that long times between galaxies means that we only need to be a once-in-a-galaxy accident

Large fraction of galaxies could have civilizations, and we would not know about it

Counterarguments to #1

- Life arose too easily on Earth to be unique
- Many other animals are close to our intelligence, so that can't be unique either

http://www.trekunited.com

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Possible Conclusion #2: Civilizations are short lived.

Assume that there are a million planets in the galaxy which form intelligent life during a 2 billion year period.

But each one is only capable of, or interested in, interstellar communication for a thousand years…how many would be there now?

On average, only one would be communicating at any given time.

Counterarguments to #2

- Colonization of other planets will make a species effectively immortal (no single thing would wipe out)
- We, and presumably aliens, have a strong drive to better technology

http://www.evlbi.org/evlbi/te024/arecibo.jpg

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Possible Conclusion #3: Interstellar travel is too hard!
And there is no shortcut!

Anybody is here now or ever was because no civilization ever developed technology to make visits reasonable.

Even though that may be hundreds or thousands of civilizations in the galaxy, each is confined to their home planet.

No colonization. No artifacts.

Perhaps communications in the future.

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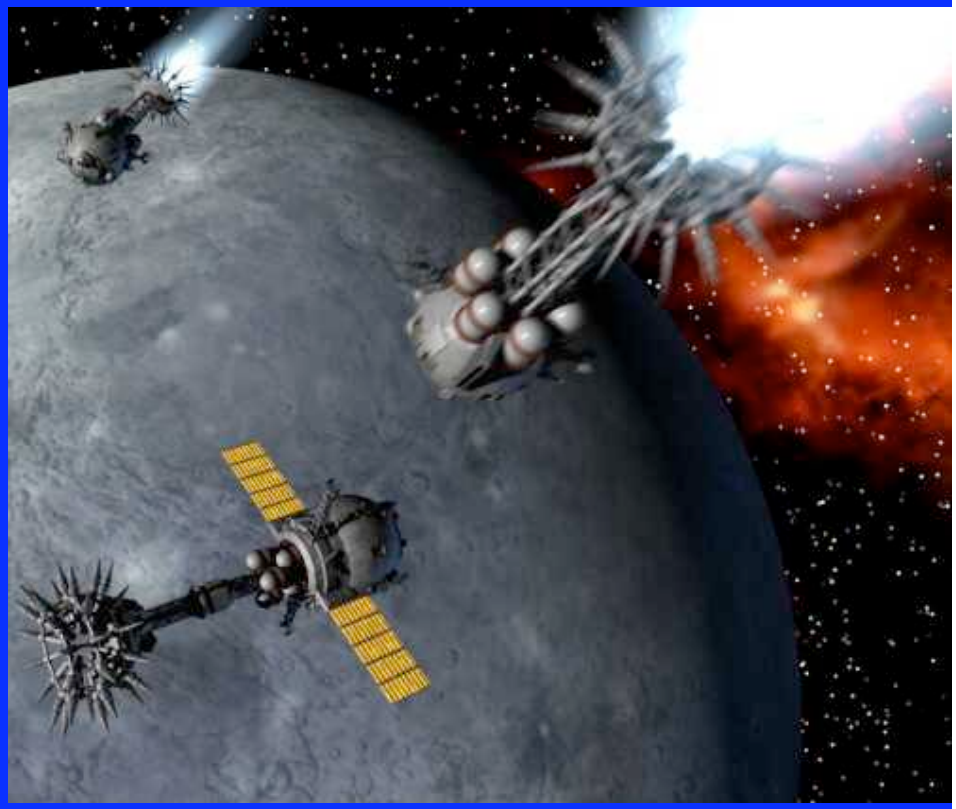
Possible Conclusion #3: Interstellar travel is too hard!
And there is no shortcut!

As part of this, it could be that resource depletion means that civilizations go through our stage and then have to retreat technologically

No interest in major expenditure needed to travel between stars

Counterarguments to #3

- Consider how far we have come in the last 100 years
- Now project 1000 years into future
- Do you really think such travel will be impossible for us?



http://www.projectrho.com/rocket/Lafayette_Surrenders_sm.jpg

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Possible Conclusion #4: Self-replicating machines are impossible!

The argument is:

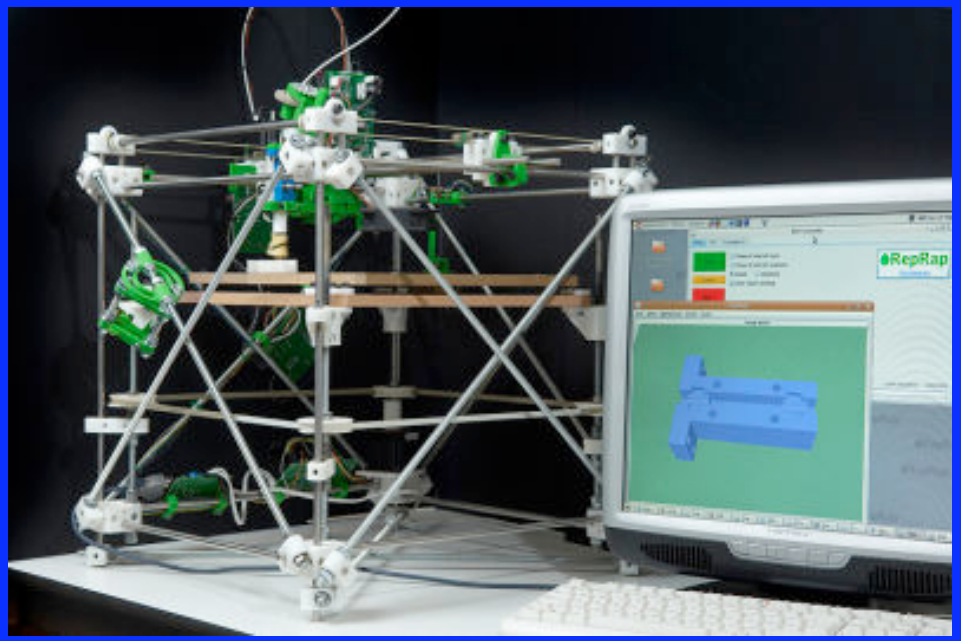
If self-replicating machines can exist, then they can spread without worry about the time that it takes.

Once capable of space travel, they can colonize the galaxy.

So why aren't they here…. Because they don't exist.

Counterarguments to #4

- But (clunky) versions already exist!
- Development is needed, but with the much better computers of the future, surely this will not be a barrier



http://futurismic.com/wp-content/uploads/2008/06/reprap-self-replicating-machine.jpg

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Possible Conclusion #5: Mature civilizations have no motivation for colonizing other worlds.

Realistically, interstellar colonization is not a solution to the problems on a planet….

It's too hard to ship many people away…

The economic return of colonization is highly questionable….

The benefit to society is questionable.

So why would a world chose to do it?

Counterarguments to #5

- All we need is *one* species with colonization impulse
- If advanced species are common, this becomes very likely

http://i.imdb.com/Photos/HH/0340485/Klingon.jpg

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Possible Conclusion #6: We live in a Zoo

The Zoo hypothesis:

There is an extensive interstellar civilization.
Earth is considered too primitive for contact.
We have been declared off-limits for now….
Observe but do not allow detection.

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Possible Conclusion #6: We live in a Zoo

Similar idea: we are simply beneath the notice of galaxy-spanning civilizations.

They only need bother with much more advanced species

Counterarguments to #6

- Again, only takes one to violate contact ban
- Might think colonizers are more aggressive, too

http://echosphere.net/star_trek_insp/insp_prime_directive.png

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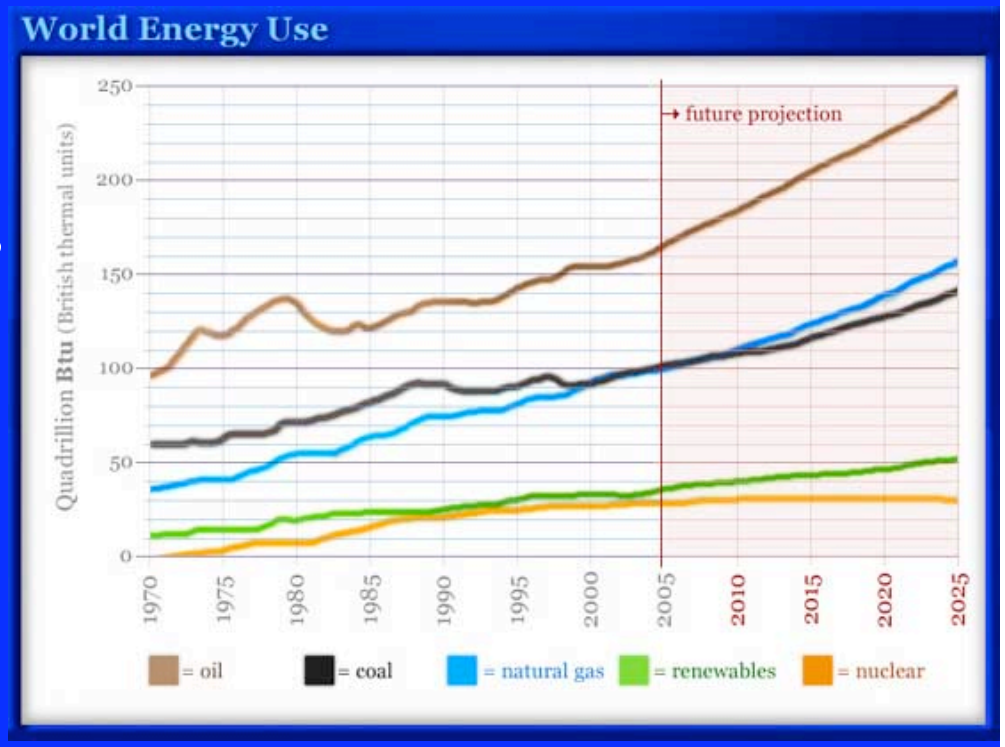
Possible Conclusion #7: We are too primitive to communicate.

The Sentinel Hypothesis:

There is an extensive interstellar civilization.
But they are plenty busy without us.
Once we have developed the proper technology,
either we will easily detect them or they will have
a sentinel program that will detect us.

Counterarguments to #7

- Human energy use is going up fast with time
- Expect same from aliens
- Galactic civilization should be anything but subtle!



http://www.seed.slb.com/en/scictr/watch/climate_change/images/worldEnergyUse.jpg

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Possible Conclusion #8: They are too alien.

Other civilizations exist and are exploring the galaxy.

But they are too alien. Perhaps they think in completely different ways. Communicate in completely different ways.

Perhaps their technology developed orthogonally to ours.

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Possible Conclusion #8: They are too alien.

Example: in David Brin's Uplift series, hydrogen-breathers have almost no intersection with oxygen-breathers

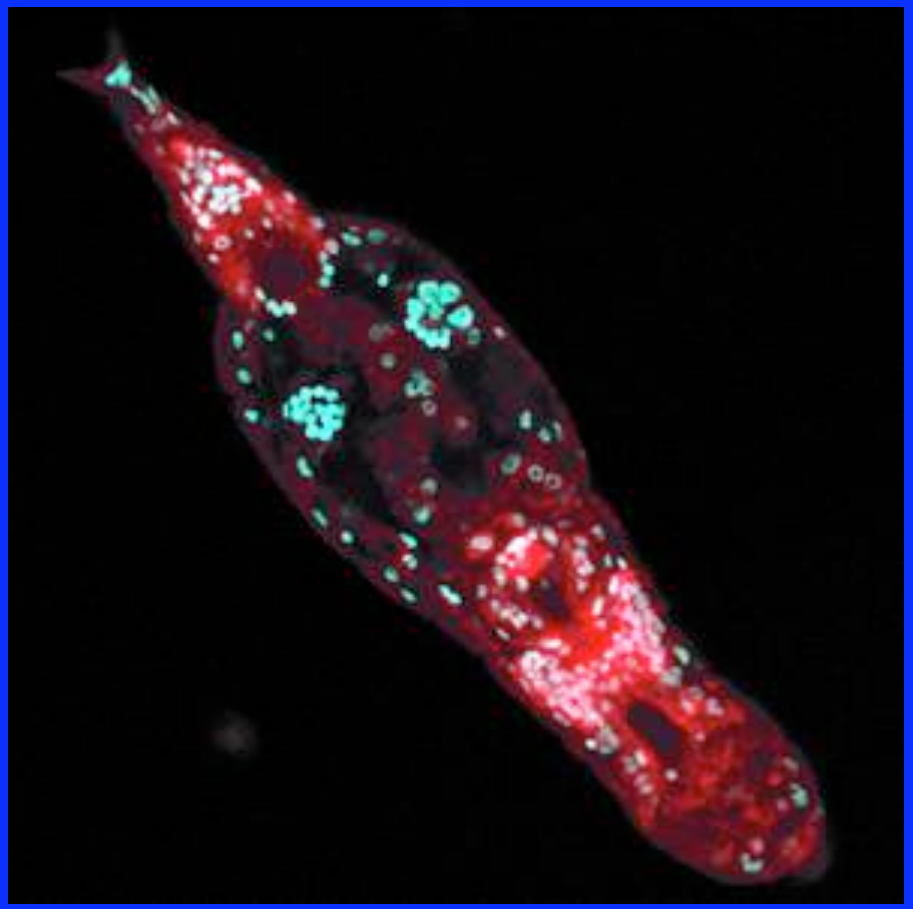
What about species that somehow live inside of stars? Not ones that evolve there, but ones that find such environments higher-energy

We might never detect them

Counterarguments to #8

- But we've detected plenty of bizarre things on Earth
- Also, advanced civilizations must have commonality (such as energy use), identifying them

Bdelloid rotifer



http://msnbcmedia1.msn.com/j/msnbc

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Possible Conclusion #9: Technology is a unique accident of our world.

Civilization exists on many planets.

But few planets have the resources to allow the full development of technology.

Perhaps the coal and oil deposits on our planet are unique.

Perhaps the combination of land, water, and plate tectonics is unique.

Counterarguments to #9

- Some energy sources, like solar power, must be universal
- Other animals on Earth construct their own tools
- Can't be that uncommon

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Possible Conclusion #10: Aliens are here observing us but their technology is so superior that we do not know it.

Nano-robots could wander the Earth freely with little chance of detection – things the size of grains of sand or fine dust.

Perhaps they are interacting with us and directing our development, protecting us….

Counterarguments to #10

- Again assumes aliens want to be delicate
- Maybe one would, but why would all?
- If aliens are here, we'd know it!

http://www.waroftheworlds.com/downloads/desktops/tripodart/wp_t1_800x600.jpg

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Possible Conclusion #11: We aren't listening and looking in the proper way yet.

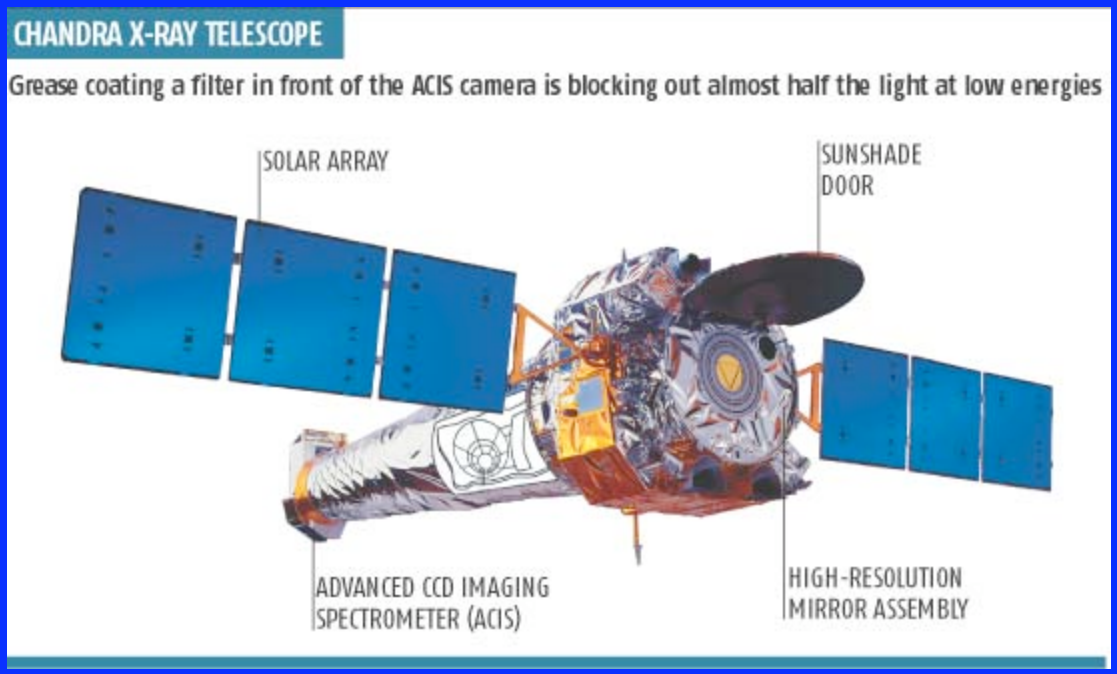
Other civilizations exist.

Space travel is too hard to do on a lark.

Civilizations communicate with each other – but using technologies that we have not yet discovered or not yet exploited.

Counterarguments to #11

- Easiest way to communicate is using photons
  Long-distance, energy-efficient
- We already observe the entire electromagnetic band
- Why would strong artificial signals escape us?



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Possible Conclusion #12: The future shown in the movie "The Terminator" never happens – machines never rule.

It can be argued that we, biological beings, are a step in the evolutionary process to thinking robots.

Thinking electro-mechanical beings could have infinite lifetimes so slow interstellar travel is no barrier.

Such beings, controlling the resources of a planet, could easily start space travel – and would colonize the galaxies in a few million years.

Hence, they do not exist.

Counterarguments to #12

- But machines are easy to construct
- Somewhere, some alien species must have done this
- Besides, no one messes with Ahnold

http://www.spiralpocus.com/wp-content/uploads/2008/05/the-terminator.jpg

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Human nature: an unavoidable consequence?

It can be argued:

- Single-celled life is easily created.
- From there on, it is evolution driven by nature selection – all the time, everywhere.
- Natural selection – survival of the fittest -- drives species to maximize their genetic advantages.
- Intelligence is an advantage to be maximized.

We humans, as a species, came to dominate other developing intelligent species on our planet due to our aggression and superior control of technology

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The development of intelligence, technology, and aggression is a direct consequence of natural selection!

Do you disagree?

Species who balance aggression and cooperation survive in the long run…. if they die, another one arises.

So any instance of life on any planet should eventually develop an intelligent species with a technical civilization.

So Fermi's paradox means...???

Votes on Solutions

- Unique in our galaxy/universe 1
- Short-lived civilizations 0
- Travel is too hard 7
- No motivation 0
- Holding off on contact 5
- We are too primitive to communicate 2
- We can't recognize them 3

Summary

- Fermi's paradox is unavoidable
- What is your favorite solution?