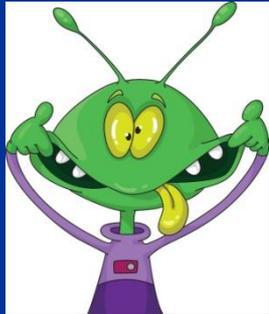


Aliens!!!



We have one data point:
no one has ever detected an alien:

1. No personal contact
2. No detection of alien ships/artifacts on Earth or elsewhere
3. No detection of signals of extraterrestrial origin

Can we ask any scientific questions about aliens?

A gray area between science and science fiction

1. Can we estimate the likelihood of alien life?
2. How might extraterrestrial life adapt to extreme environments?

Estimating the abundance of alien life:

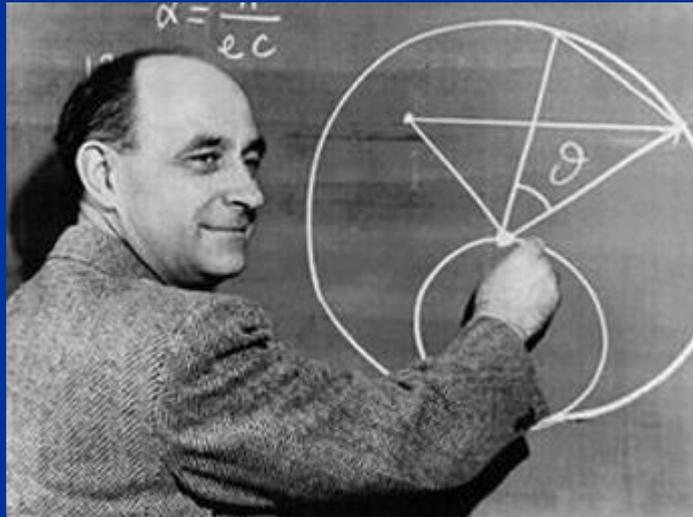
A “back of the envelope calculation”
or a “Fermi Problem”

How much coal would it take to power the US
for a year?

How many air travellers are in the air right now?

How many piano tuners are there in Chicago?

The original Fermi Problem:
How many piano tuners live in Chicago?



How many people live in Chicago?

9 million

How many households in Chicago?

4.5 million (2 people per household)

How many households have pianos that get tuned regularly?

(1 out of 20) = 225,000 tunings per year

A typical work year is 2000 hours, and it takes about 2 hours to tune a piano, so a piano tuner does 1000 tunings in a year.

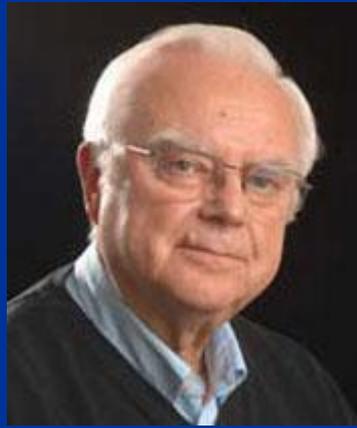
So Chicago employs about 200 piano tuners

How many aliens are there??

1. How many stars are in the galaxy?
2. How many of these stars have planets?
3. How many planets develop life?
4. How many planets with life develop intelligent life?
5. How many of the intelligent aliens will broadcast their existence?

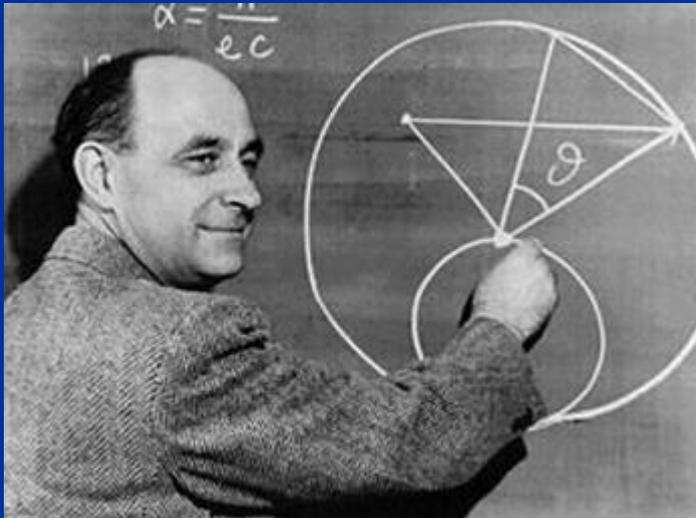
The (in)famous Drake Equation:

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



If intelligent life is common,
where are all the aliens?

The “Fermi paradox”



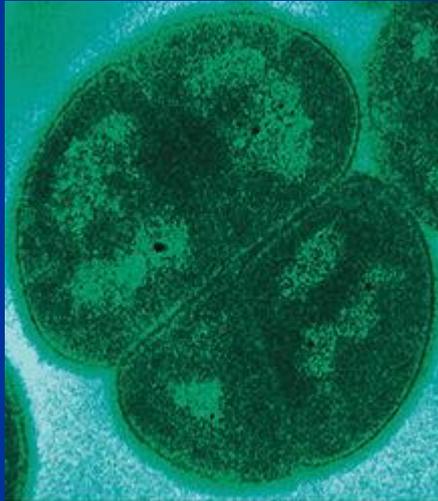
Solutions to the Fermi Paradox:

1. Intelligent life is rare
2. Intelligent life is common, but something prevents contact with us
3. Intelligent life is common; we just don't know it for some reason

Maybe all life is rare

Hard to believe:

1. Planets are plentiful
2. Life arose right after the earth formed
3. Life on earth is incredibly hardy



But maybe there is something special about our solar system

1. Our moon is unusually large – stabilizes earth's axis and leads to large tides and tidal pools



2. Jupiter scoops up debris and protects the earth from impacts?



Maybe life is common, but intelligent life is rare (insert favorite joke here)

Life developed soon after the earth developed, but intelligent life developed only recently

Maybe intelligence is overrated as a survival trait (dinosaurs have survived far longer than us, and insects still outnumber us)

Maybe intelligent life is common, but contact is difficult for some reason

Does life inevitably destroy itself?



Dangers:

1. Nuclear war
2. Nanotechnology
3. Ecological catastrophe
4. Astrophysical hazards?
5. Viral/bacterial destruction (natural or artificial)

Martin Rees: Our Final Hour

Anders: “The Fermi Paradox is our Business Model”

Other reasons intelligent life might have gone undetected:

Space travel is hard (but what about our self-replicating probes?)

We're listening wrong (TV/radio broadcasts, but now we have cable)

Intelligence/tool-using is ephemeral
(Barnes and Niven: "The Locusts")

Deadly probes hypothesis (it's dangerous out there, so keep quiet!)

Fred Saberhagen: Berserker series

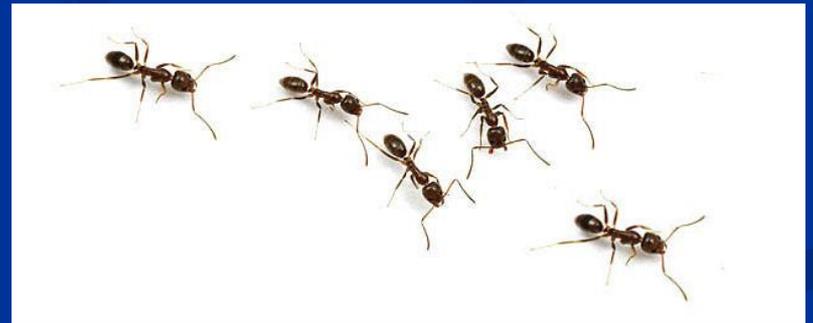
Transcendence: Intelligence evolves to something beyond our understanding, downloads into computers, etc.

They're out there; we just don't know it!

1. So alien we don't recognize them

Bisson: "They're Made out of Meat"

Maybe they even live here on earth?



Maybe we *have* been contacted



Zoo/ Interdict/ “Prime Directive”

Directed panspermia: *We are* the aliens

Planetarium hypothesis

Simulation hypothesis

They're hiding!

How would life adapt to extreme environments?

Is there life in the solar system?

Mars?

Moons of Jupiter? Europa?

NASA studies extremophiles on earth for clues

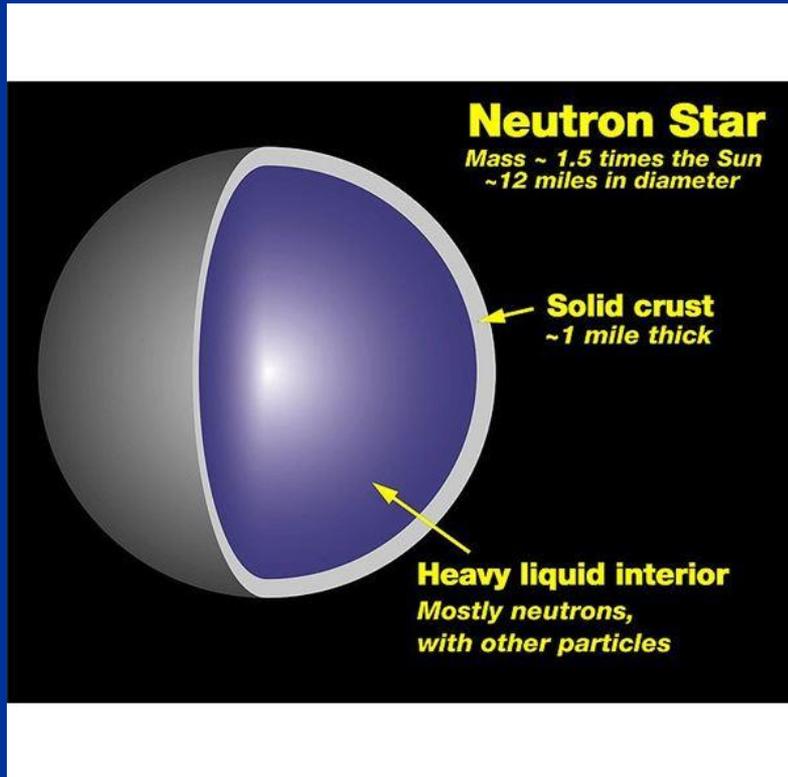
Science fiction has explored much wilder possibilities

Hal Clement: *Mission of Gravity*



Mesklinites

Robert Forward: *Dragon's Egg*



The Cheela

Larry Niven: *Known Space* series

An entire galactic zoo



How to communicate with extraterrestrials:

Radio?

Documents on space probes?

How about:

Messages embedded in DNA?

A message encoded in the cosmic microwave background?

A message in the digits of pi? (Carl Sagan)

Next Week

Quantum Mechanics

“Quantum Theory Tugged, and All of Physics Unraveled” (NY Times):
<http://www.nytimes.com/2000/12/12/science/12QUAN.html>

Robert Charles Wilson, “Divided by Infinity”
<http://www.tor.com/stories/2010/08/divided-by-infinity>

Larry Niven, “All the Myriad Ways”

Time Travel

Robert Heinlein, “By His Bootstraps”

William Tenn, “The Brooklyn Project”