

**Are we alone?**

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Astrobiology asks three fundamental questions - what are the chances that:

- Other life exists?
- Other advanced (multicellular) life exists?
- Other (technological) intelligent life exists?

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The arguments for life being common are:

- Sun-like stars are common,
- Earth-like planets are probably common,
- Life formed so quickly on the Earth it must be fairly easy **given the right conditions.**

When arguing that advanced and intelligent life must be (at least fairly) common there are two further arguments:

- Once life has formed it will evolve into more and more complex forms and into advanced (multicellular) lifeforms,
- Once advanced life is present intelligence is an evolutionary advantage and will automatically arise. (And then technology and civilisation will follow.)

# The Fermi Paradox

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The Fermi Paradox asks the question:

If there are other intelligences out there – where are they?

This is based on the following arguments:

- It should be possible to build self-replicating probes (von Neumann probes).
- These can explore the entire Galaxy in  $<10$  Myr.

So why aren't they here already? And why can we see no signs of them anywhere in the Universe?

# Possible solutions

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There is an entire literature on possible solutions to the Fermi Paradox:

- Galactic Zoo hypothesis.
- Self-destruction of intelligences.
- Why bother to explore/colonise?
- The singularity (post-biological evolution).
- They don't exist.

# The Rare Earth hypothesis

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Why would there be so few (no) other intelligences. Is there something special about the Earth?

- A large Moon.
- Active plate tectonics.
- A quiet Sun.
- Wandering giant planets (out not in).
- Galactic habitable zone.
- Is there something special about evolution on Earth? Was it fast? Was it a series of incredibly lucky accidents?
- Is **technological** intelligence common?

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There is a general feeling in astrobiology that basic life is probably common.

But for advanced life we have no idea yet, but new instruments should give us a basic idea over the next 20 years.

As for technological intelligence, we have no idea, but many astrobiologists think we are rare, maybe unique!

Is the solution to the Fermi paradox that we are the first?

Or do we not even exist in the way we think we do?