

*The Fermi Paradox

The Rare Earth Hypothesis

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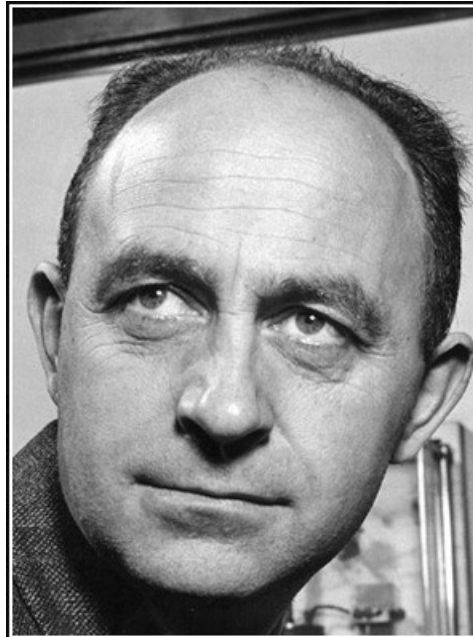
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***You are what you Do**

Who was Fermi?

- Nobel prize for physics in 1938
- Created the first nuclear reactor
- Architect of the Nuclear Age



Before I came here I was confused about this subject. Having listened to your lecture I am still confused. But on a higher level.

— Enrico Fermi —

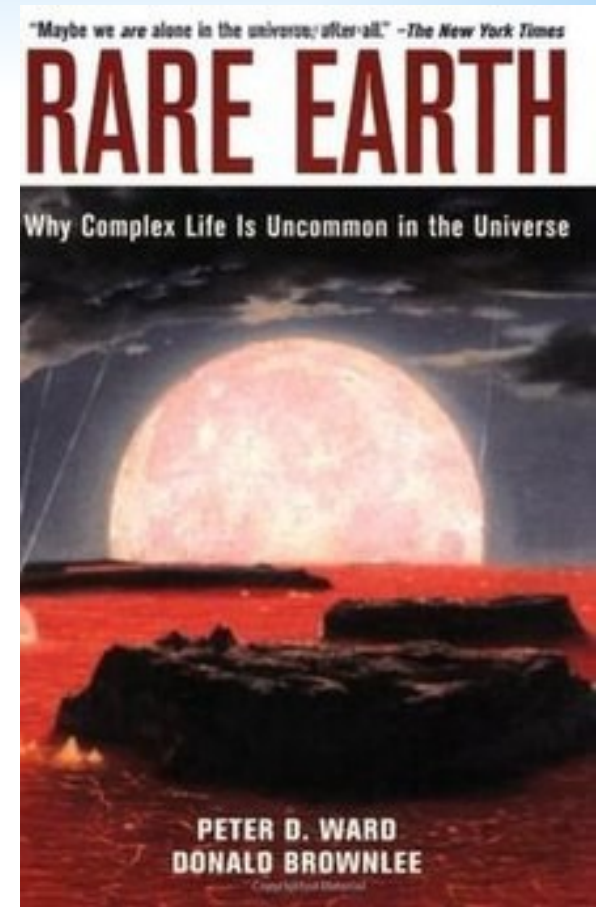
AZ QUOTES

The discrepancy between the lack of conclusive evidence of advanced extraterrestrial life compared to the high likelihood of its existence.

Why was he so Paradoxical?

The Rare Earth Hypothesis

- There is a lack of clear, obvious evidence.
- But a high estimate of their existence.
- We are alone or so far distant as to be unapproachable.
- Often called the Great Filter theory.
- Life must overcome hurdles, one nearly impossible to clear.



Why don't they want to play?

How It Works

- Identify the topic.
- Panelists discussion.
- Audience participation.
- Next topic - rinse, wash - repeat.
- Closing thoughts and discussion.
- Off-topic conversations will be deferred.



Icon mean Q&A.

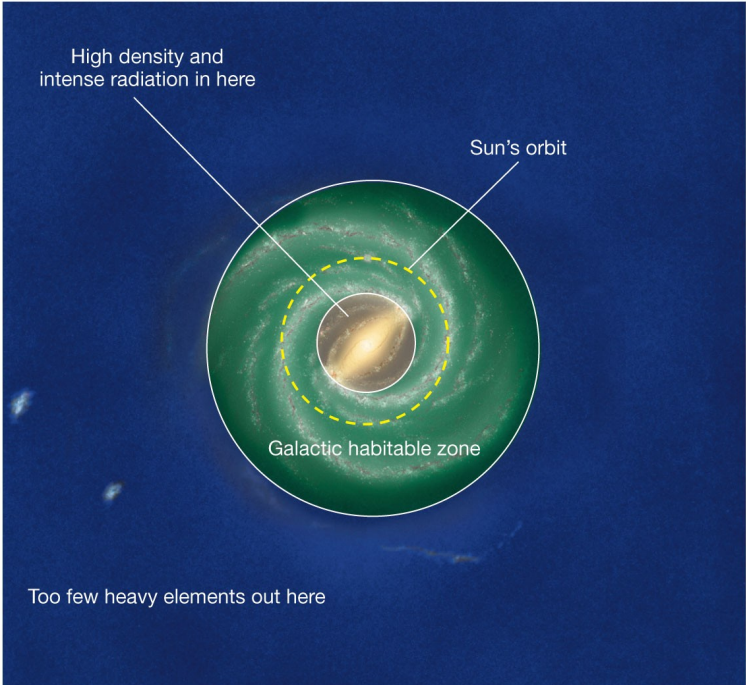
A Few Topics to Consider

- Goldilocks zone filters.
- Planetary formation filters
- Biotic filters for abiogenesis.
- Evolutionary filters.
- Cultural filters for science, industry, and exploration.
- Thoughts from the Peanut Gallery.



But I need proof - no I don't!

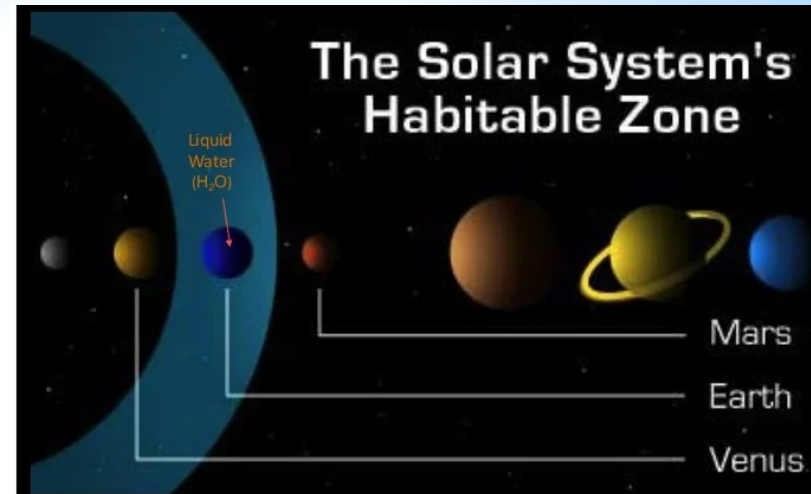
Goldilocks Zone Filter

- The Galactic center is mostly older, metal-poor stars of hydrogen, helium, and lithium.
 - Metal-poor stars are less likely to have rocky planets.
 - Flooded with life-destroying gamma rays, x-rays, and cosmic rays.
- 
- High density and intense radiation in here
- Sun's orbit
- Galactic habitable zone
- Too few heavy elements out here
- © 2011 Pearson Education, Inc.
- The gravitational tug of closely packed stars would perturb the orbit of comets, increasing the impacts.

So what's your neighborhood like?

Earth-Sun is unique.

- Earth is in a Goldilocks zone, allowing liquid water.
- Yellow dwarf, 2nd – gen star with heavy elements.
- Our sun has a long lifespan –ten billion years.



- Sun doesn't give off excessive ultraviolet radiation.
- Gas giants soak up debris and comets.

Not too cold. Not too hot. Just right!

Questions - Goldilocks Zone

- The Goldilocks zone is the habitable area around a star where it's not too hot or cold for liquid water to exist on a rocky Earth-like planet.
- How do the Goldilocks zones impact the development of Extra Terrestrial Civilizations (ETC)?
- The Galactic habitable zone is the region of a galaxy in which life is most likely to develop.
- What are the factors impacting habitable worlds near the Galactic core?

Not too cold. Not too hot. Just right!

Goldilocks Zone Filters



There's no place like home!

Planetary Filters

- Why is a large moon so important?
- Why is Plate Tectonics so important?

When the Moon hits your eye...

Earth-Moon is unique

- A large moon is vital for early life:
 - Produces tides that distribute heat,
 - Tidal pools help form amino acids,
 - Stabilized Earth's rotation, and
 - Produces a tilt that provides seasons.
- Did the moon have an early magnetic field, shielding Earth from harsh radiation?
- Earth-Moon binary, rocky planets may be rare.

My moon's bigger than your moon.

Plate Tectonics is unique

- Geothermal and Plate Tectonics:
 - Maintains a dynamic surface environment,
 - Promotes biodiversity with diverse habitats,
 - Regulates the climate over millennia, through the Carbon cycle, and
 - Hydrothermal vents are possibly the genesis of life.
- How common are tectonics in solar systems?

Did the earth move for you too?

Questions - Planetary Filters

- The Earth has a large moon, which some refer to as a binary planet system.
- What is the significance of binary planet systems, on the development of complex life and an ETC?
- Earth has large oceans and continents in constant motion due to plate Plate Tectonics.
- What is the impact for developing advanced life and an ETC?

I don't mean to find fault, but!

Planetary Filters



There's no place like Earth.

Abiogenesis Filters

- What is Abiogenesis?
- Proposed pathways to life.
- Evolution of metabolic pathways.

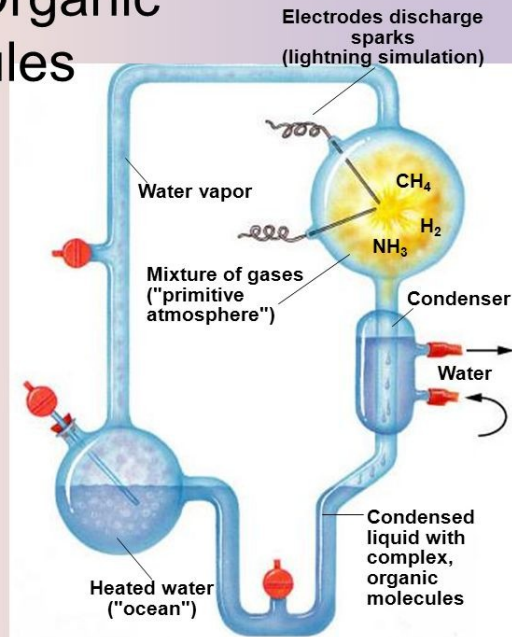
I don't mean mice from wet hay.

What is Abiogenesis

- Abiogenesis is the origin of life from nonliving matter.
- Oparin & Haldane (1920s) proposed the initial atmosphere contained ammonia, carbon dioxide, hydrogen, and carbon.
- Urey-Miller's created amino acids.

Origin of Organic Molecules

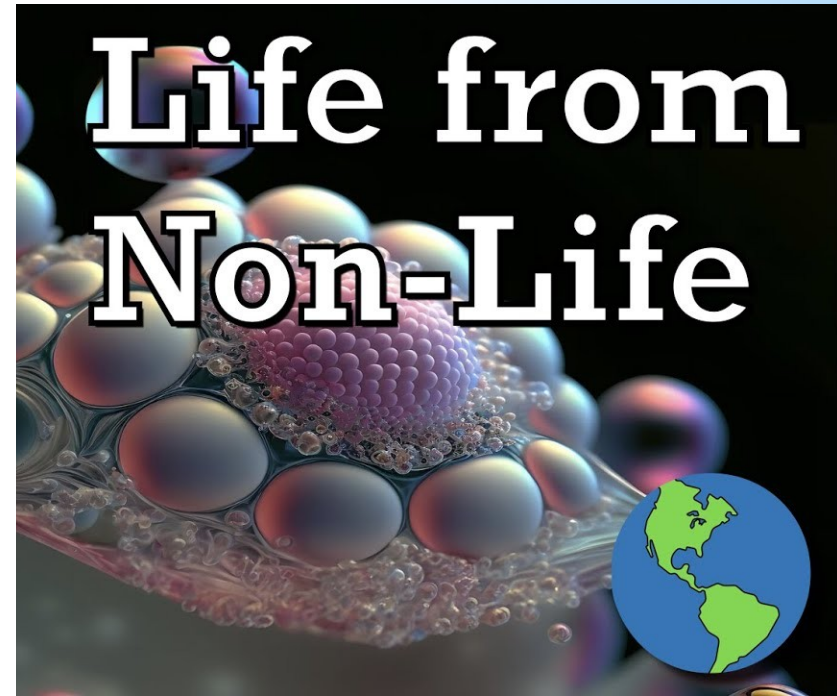
- Abiotic synthesis
 - 1920 Oparin & Haldane propose reducing atmosphere hypothesis
 - 1953 Miller & Urey test hypothesis
 - formed organic compounds
 - amino acids
 - adenine



Beginnings – how we got here.

Proposed Pathways

- Replication first: Organic molecules become DNA segments that can replicate themselves.
- Metabolism first: Organic molecules integrating substances from their surroundings.
- RNA World: Organic molecules become precursor RNA segments that can produce DNA.



How do simple compounds create life?

Biotic Filters for Abiogenesis

- Abiogenesis requires a continuous process between non-living – abiotic, and biotic-living chemistry, evolving with increased stability.
- No theoretical pathway exists from organic molecules to a life form.
- No mechanism exists for RNA segments to evolve into full RNA molecules.
- No consensus exists on how replicating/ metabolizing molecules become life forms.

Abiotic becoming biotic chemistry?

Questions - Abiogenesis

- The Urey-Miller experiment demonstrated that under-theorized primordial Earth conditions, amino acids could be produced. Yet no clear pathway has been proposed for non-living abiotic chemistry to become living biotic chemistry. No theoretical evolutionary metabolic pathway for complex cells has been proposed.
- How likely are the conditions to create life, let alone complex life with organic molecules like RNA and DNA?

Life from Non-Life

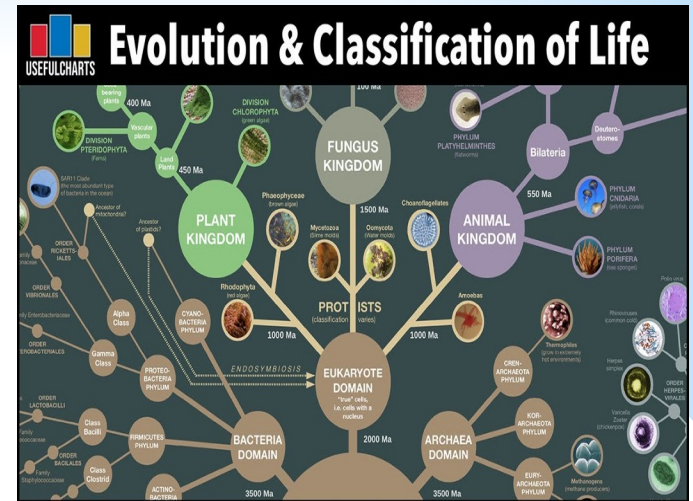
Abiogenesis Filters



I'm just a chip off the old amino
acid.

Evolutionary Filters

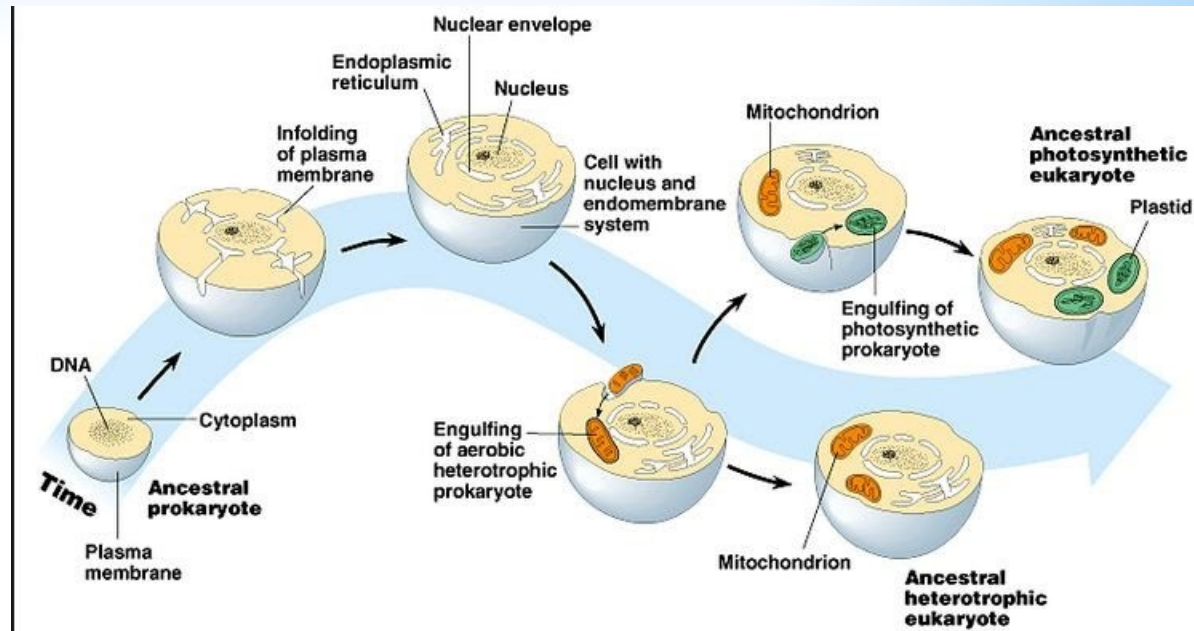
- How did simple life evolve into complex life?
- Was the Great Oxidation Event inevitable?
- What if the Cambrian explosion never occurred?



From one cell to Marilyn Monroe.

Endosymbiotic Theory

- Archaea cells fused after engulfing a bacteria cell.
- Prokaryotes are simple cells, with a single strand of circular DNA.



- Eukaryota: linear DNA within a nucleus, mitochondria, and membrane-bound organelles with cellular functions.
- What if complexity is a barrier?

Oh baby give me your ATP!

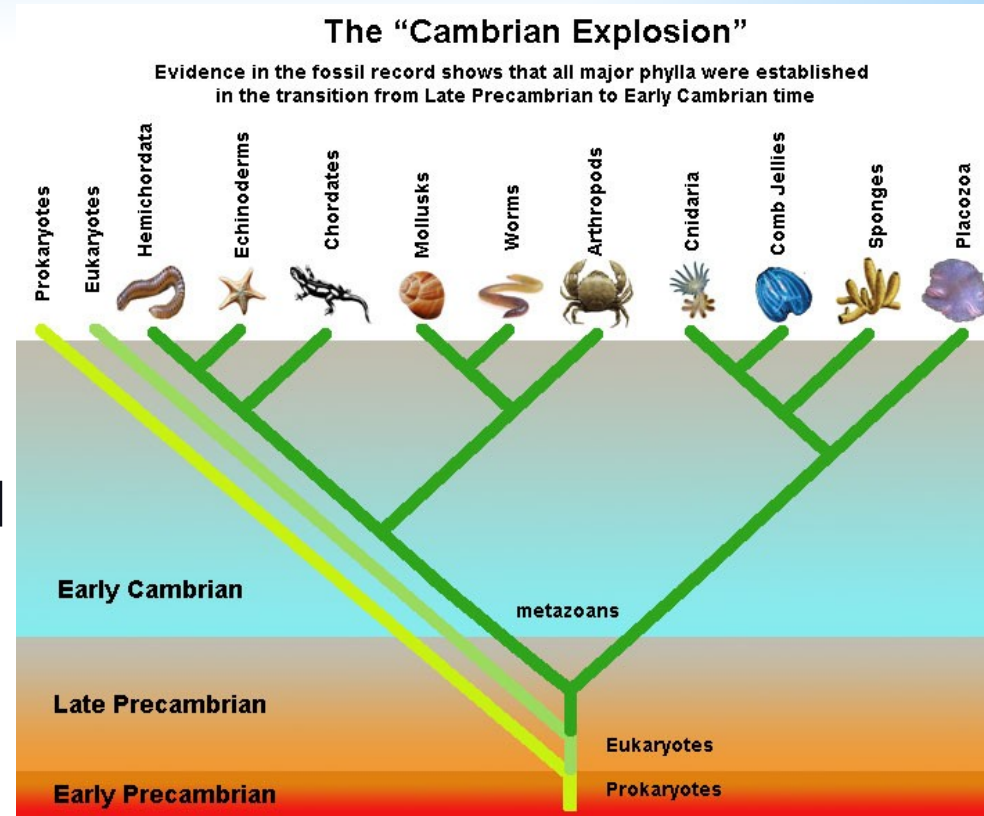
The Great Oxygenation Event

- The Initial atmosphere was CO_2 , CH_4 , and H_2O .
- Evolution of Cyanobacteria performed photosynthesis.
- Oxygen creates ozone (O_3) and reacts with methane.
- Ozone prevents harmful UV radiation.
- Increased O_2 permits complex metabolic activity.
- Enzyme evolution permits multicellularity and large complex animals.
- Would complex life even evolve without Oxygen?

Photosynthesis will kill us all!

The Cambrian Explosion

- Major phyla of modern animals appear (541 – 530).
- Weathering from plate tectonics increased levels of phosphorus and CO₂.
- Driving photosynthesis and O₂ production.
- What if the Cambrian explosion didn't occur?



Get a backbone you spineless worm.

What if Hominidae Didn't Evolve

- Cognitive functions require a large cranial capacity.
- Dexterous, grasping appendages with fine motor control, capable of creating sophisticated tools.
- Ability to carry heavy burdens.
- Ability to build large structures.
- Have complex cooperative social networks.

Stop monkeying around!

Questions - Evolutionary Filters

- With the Great Oxygenation Event and Plate Tectonics, conditions were ripe for the development of complex life, due to the increase in O₂ and trace elements like Phosphorous.
- What if only one or neither condition existed? Would complex life still evolve?

Stop monkeying around!

Questions - Evolutionary Filters

- Humans have dexterous grasping appendages with fine motor control, which permit the creation of sophisticated tools, and live in complex, cooperative social structures.
- How important are various physical traits of humans for the development of an ETC?

Look, Ma, I've got thumbs!

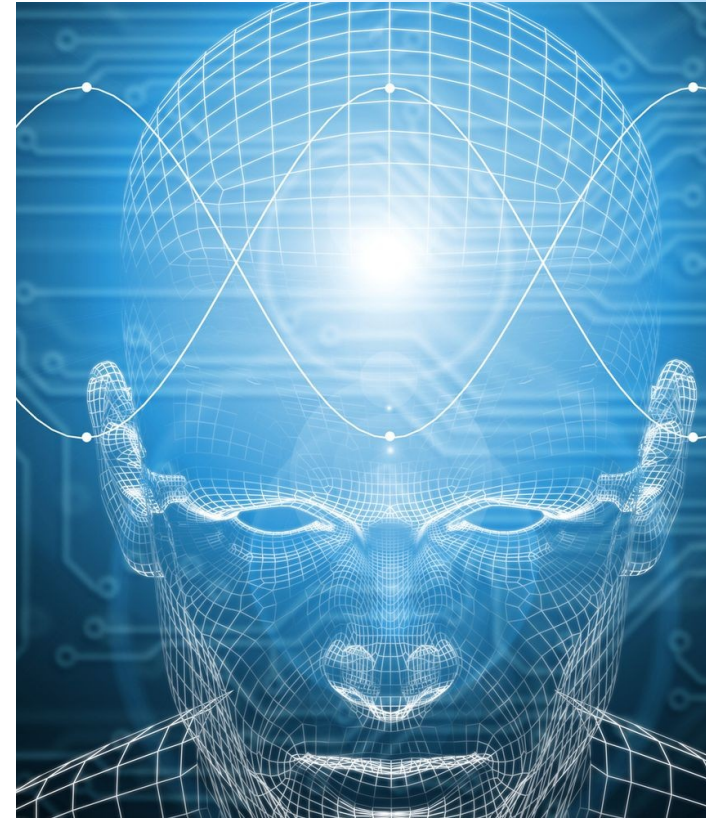
Evolutionary Filters



I'll be a monkey's uncle!

Anthropomorphic Principle

- Derive expected properties based on Earth life, and human civilization.
- We have a test case of ONE.
- Is the Anthropomorphic Principle valid?



How would they differ?

Cultural Filters - What if's

- The scientific revolution didn't happen.
- The industrial revolution didn't happen.
- The expansion of trade economies didn't occur.



All I need is right here!

Scientific Revolution

- The Scientific Revolution (1500 – 1700), occurred in Europe and spread worldwide.
- It paved the way for the scientific method of critical thinking.
- It promotes advancements in technology and economic development.
- What if the scientific revolution didn't happen?

From mysticism to empiricism.

Industrial Revolution

- The Industrial Revolution began in the late 18th century and continued into the 19th century.
- Agricultural advancements led to higher crop yields.
- The invention of the steam engine, the spinning jenny, and the power loom revolutionized textiles, transportation, and manufacturing.
- Increased the demand for skilled labor, education, and training.
- Paved the way for technology advancements, and the Digital Revolution.
- Would spaceflight even be possible without it?

Cottage Industry to Manufacturing.

Cultural Filters - What if's

- What if we never migrated from small villages?
- What if we didn't expand our horizons, through international trade?
- What if the voices telling us to stay home prevailed?
- Exploring the solar system is:
 - Dangerous,
 - Expensive, and
 - Everything needed is on Terra firma.

Baby, it's cold outside.

Questions - Cultural Filters

- Human beings are contentious, adventuresome, and highly competitive. We quickly colonized our planet and developed complex trading networks.
- Given how dangerous, expensive, and disruptive exploration, and colonization are, what is the motivation for an ETC to move from their village, leave their planet, or explore other solar systems?

Lions and Tigers and Bears, oh my!

Cultural Filters



I'm proud little Luddite!

Questions - The Dark Forest

- The Dark Forest postulates that the reason we don't find any evidence of an ETC is that they are purposely staying dark. This is to prevent other ETCs from eliminating them as a threat.
- Is this a valid scenario?

Baby, it's cold outside.

Questions - The Void/Zoo

- It has been proposed that our solar system exists in a vast Galactic void.
- Does a Galactic void explain why we have not had contact with an ETC?
- IF ETC has a Galactic “Do not disturb sign” on Earth, how likely is it they would honor their Prime Directive?

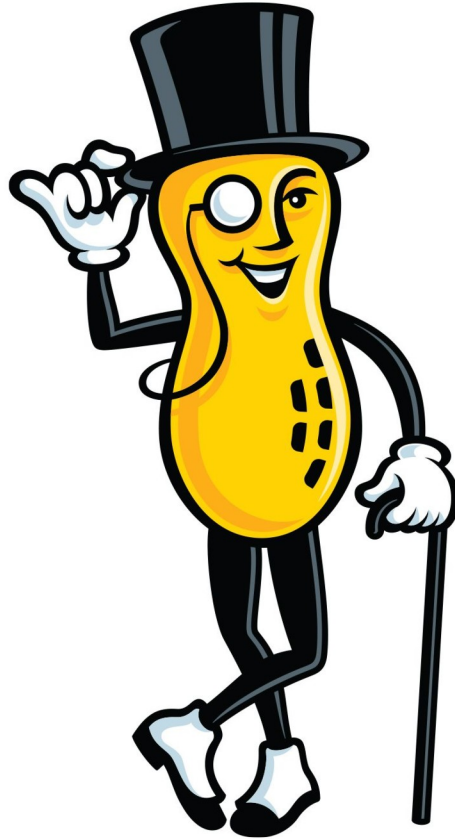
Not in my neighborhood.

Questions - Other

- What if ETC is incredibly alien, such as non-carbon-based life, or intelligent-based microbes?
- Would we even know they exist, or would communication be possible?

We just aren't communicating.

Closing Thoughts



And the Peanut Gallery says!

Credits

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Check my math