

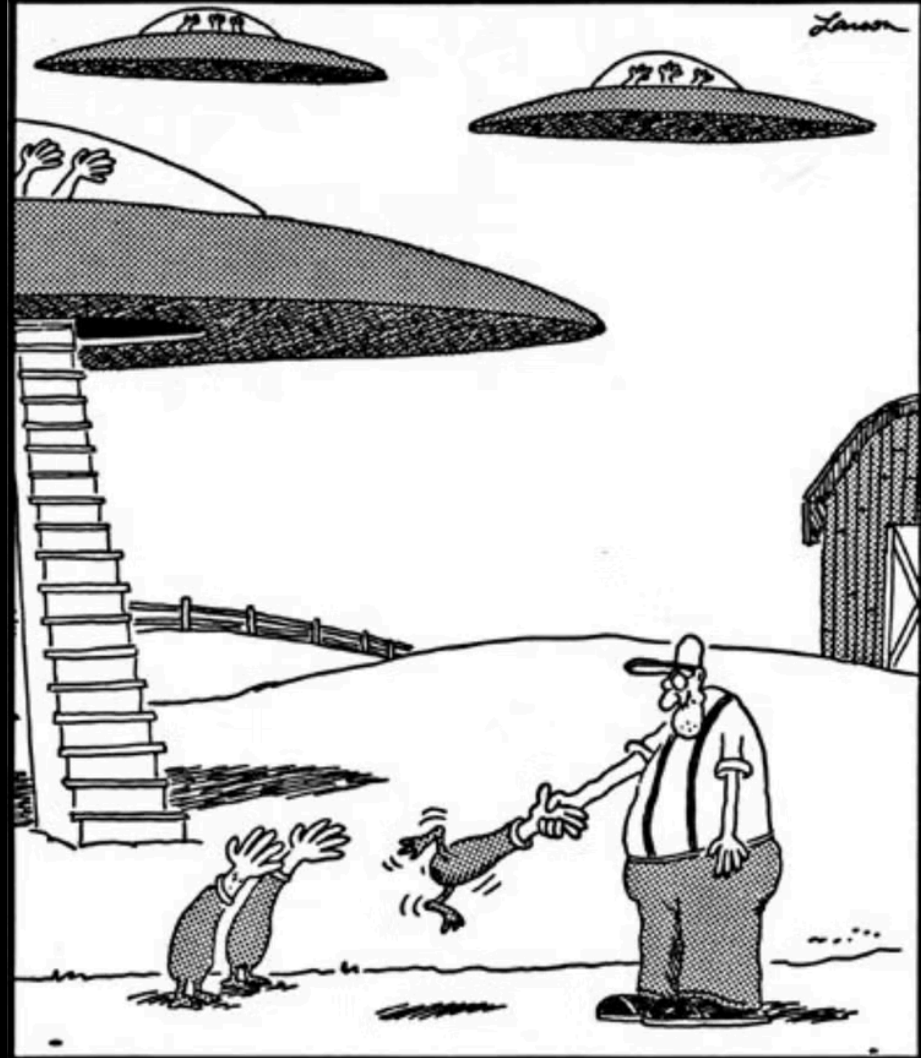
Is There Anyone Out There?



Peterborough Astronomical Association
Novice Astronomy Class
February 6, 2026
Brett Hardy

UFO Phenomena

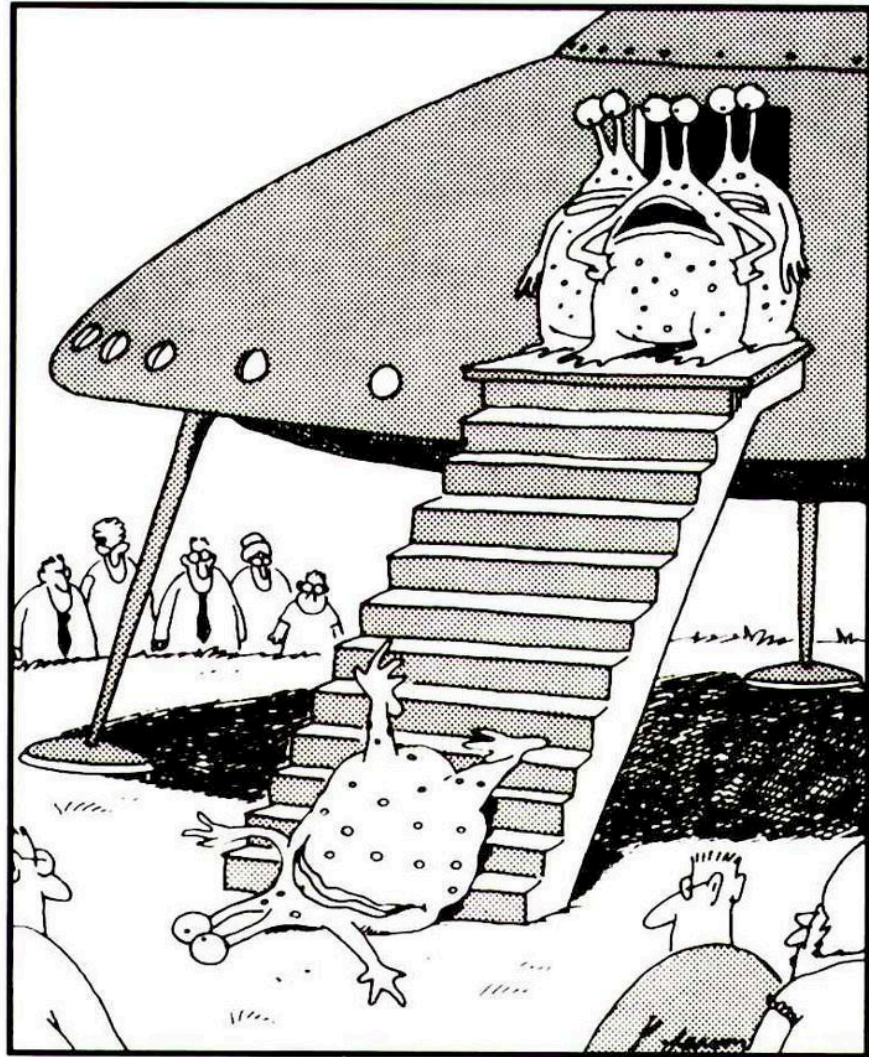
- Roswell incident June 14, 1947
- June 24, 1947 & Kenneth Arnold
- Are *they* already here?



Inadvertently, Roy dooms the entire earth to annihilation when, in an attempt to be friendly, he seizes their leader by the head and shakes vigorously.

Fermi's Paradox

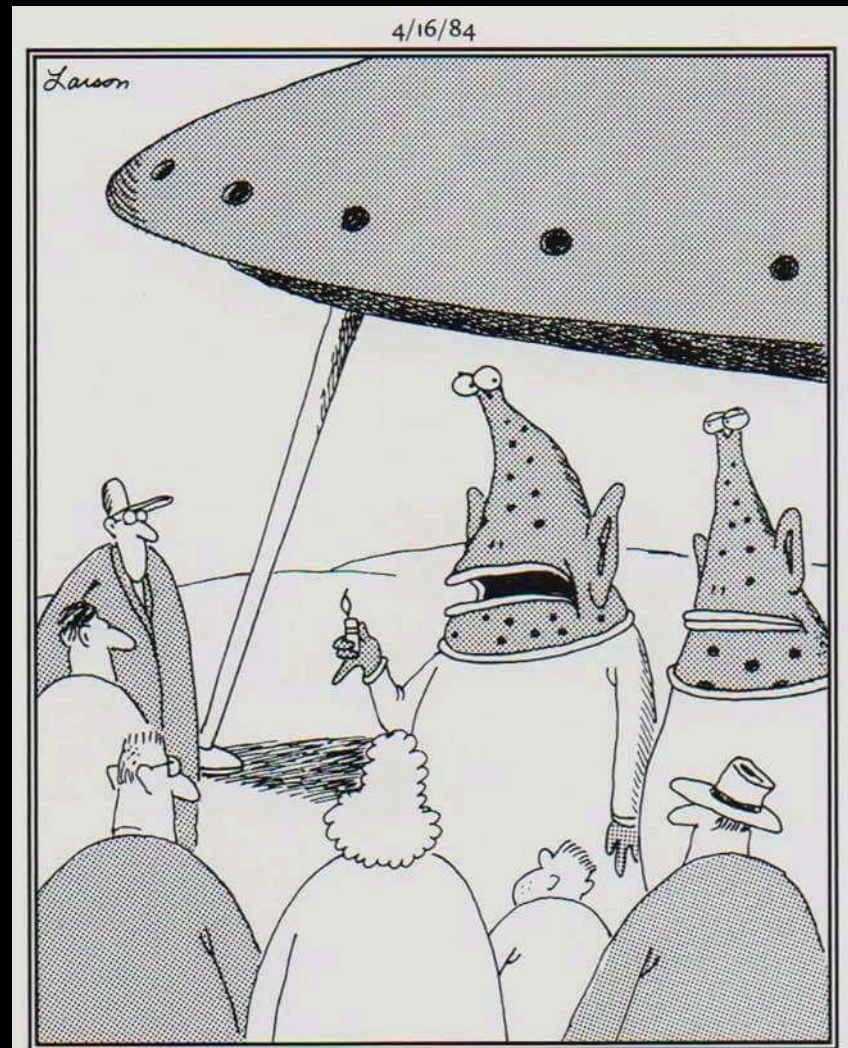
- Los Alamos, New Mexico 1950
- "But where is everybody?"



"Wonderful! Just wonderful! ... So much for instilling them with a sense of awe."

The Drake Equation

- Frank Drake
- Project Ozma 1960 (April – July)
Green Bank Observatory, West Virginia
- National Academy of Sciences
1961
- How many advanced technological civilizations are there in the Milky Way Galaxy?
- $N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$
- Search for Extraterrestrial Intelligence - SETI



“Well, they’re unimpressed. ... And now what are we going to do with fifty cases of butane lighters?”

N^* Number of Stars in the Milky Way Galaxy

- This is the factor we actually have a decent handle on
- For scientists, that means we are fairly certain that there are between 100-500 billion stars in the Milky Way

400,000,000,000

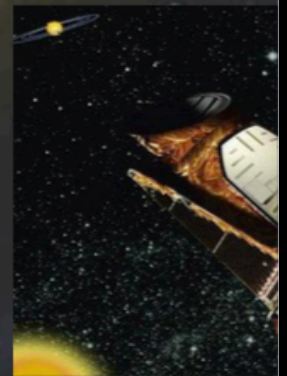
$$N = N^* \cdot f_p \cdot n_e \cdot f_\ell \cdot f_i \cdot f_c \cdot L/T_g$$

f_p What Fraction of Stars Have at Least One Planet?



Current estimates:

- On average, stars will have at least 1 planet orbiting them!
- Scientists are refining this estimate all the time with missions like JWST



$$N = N^* \cdot f_p \cdot n_e \cdot f_\ell \cdot f_i \cdot f_c \cdot L/T_g$$

n_e How Many of These Worlds Have the "Right" Environment?

What does "Right" mean?

- Small, rocky planet
- That has a heat source
 - Habitable Zone
 - Tidal heating
- And an atmosphere

What we're really looking for is...

$$N = N^* \cdot f_p \cdot n_e \cdot f_t \cdot f_i \cdot f_c \cdot L/T_g$$

f_ℓ How Many Habitable Planets Develop Any Life Forms?

(at any point)

Start with what we know:
Our Solar System

Just 1 that we know of
- Earth!



$$N = N^* \cdot f_p \cdot n_e \cdot f_\ell \cdot f_i \cdot f_c \cdot L/T_g$$

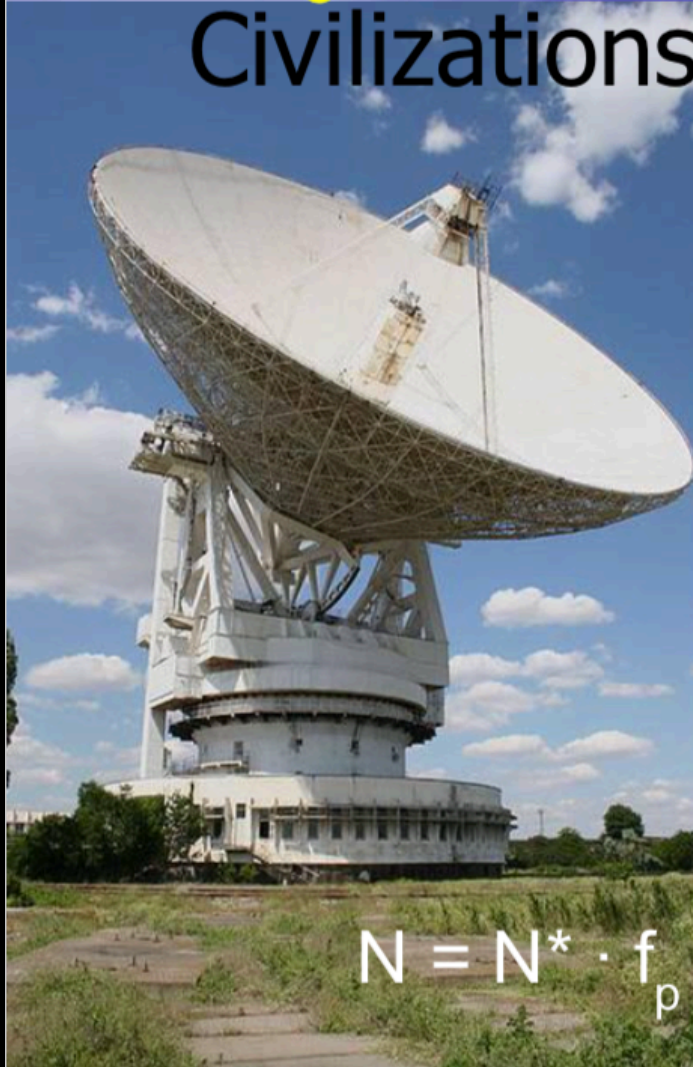
f_i How Often Does Simple Life Become Intelligent?

- Billions of species have existed on Earth. Only one seems to have looked out into the galaxy for company
- Does life always become more complex over time?

$$N = N^* \cdot f_p \cdot n_e \cdot f_\ell \cdot f_i \cdot f_c \cdot L/T_g$$



f_c How Many Intelligent Civilizations Communicate?



- These civilizations are able and willing to communicate
- Is it possible that they are out there in listen-only mode?

$$N = N^* \cdot f_p \cdot n_e \cdot f_\ell \cdot f_i \cdot f_c \cdot L/T_g$$



L Average Lifetime of a Communicating Civilization

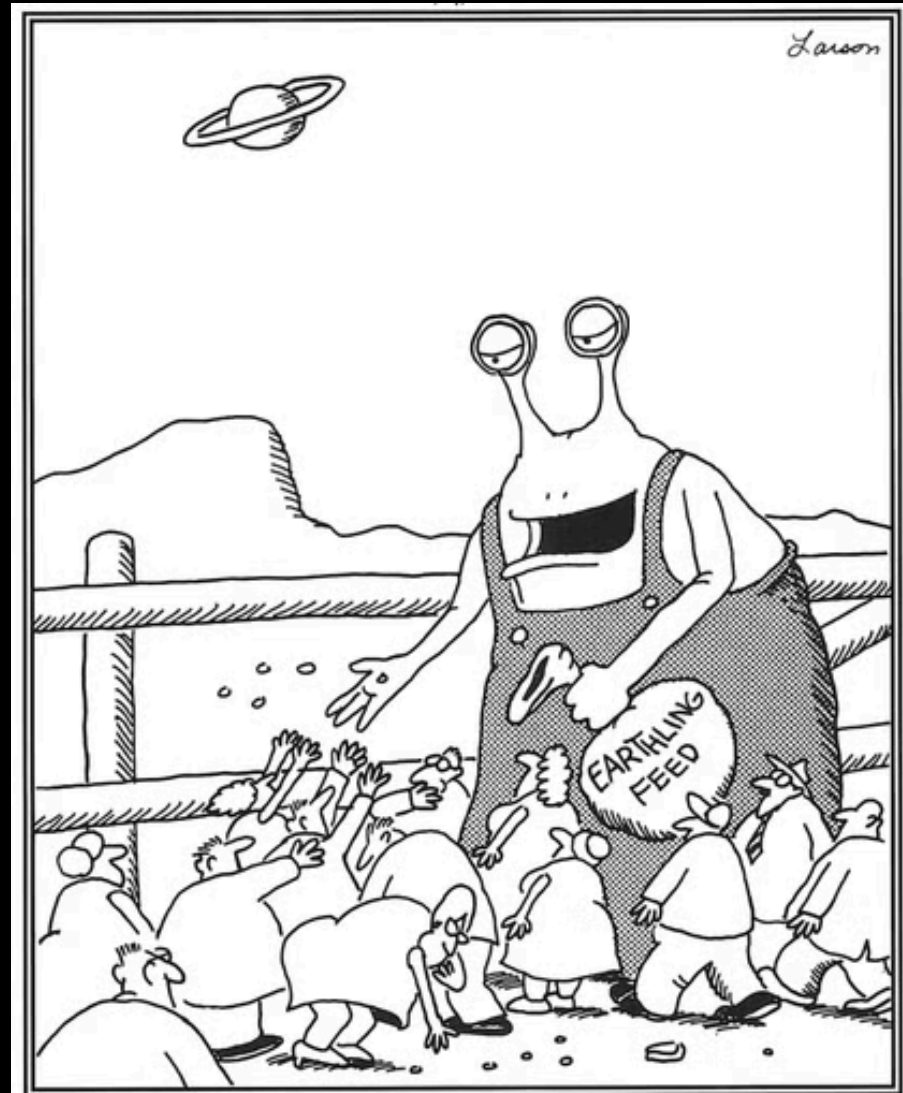
We have been communicating for less than a century

How long will we survive?

$$N = N^* \cdot f_p \cdot n_e \cdot f_\ell \cdot f_i \cdot f_c \cdot \frac{L}{T_g}$$

Cosmological & Geological Accidents

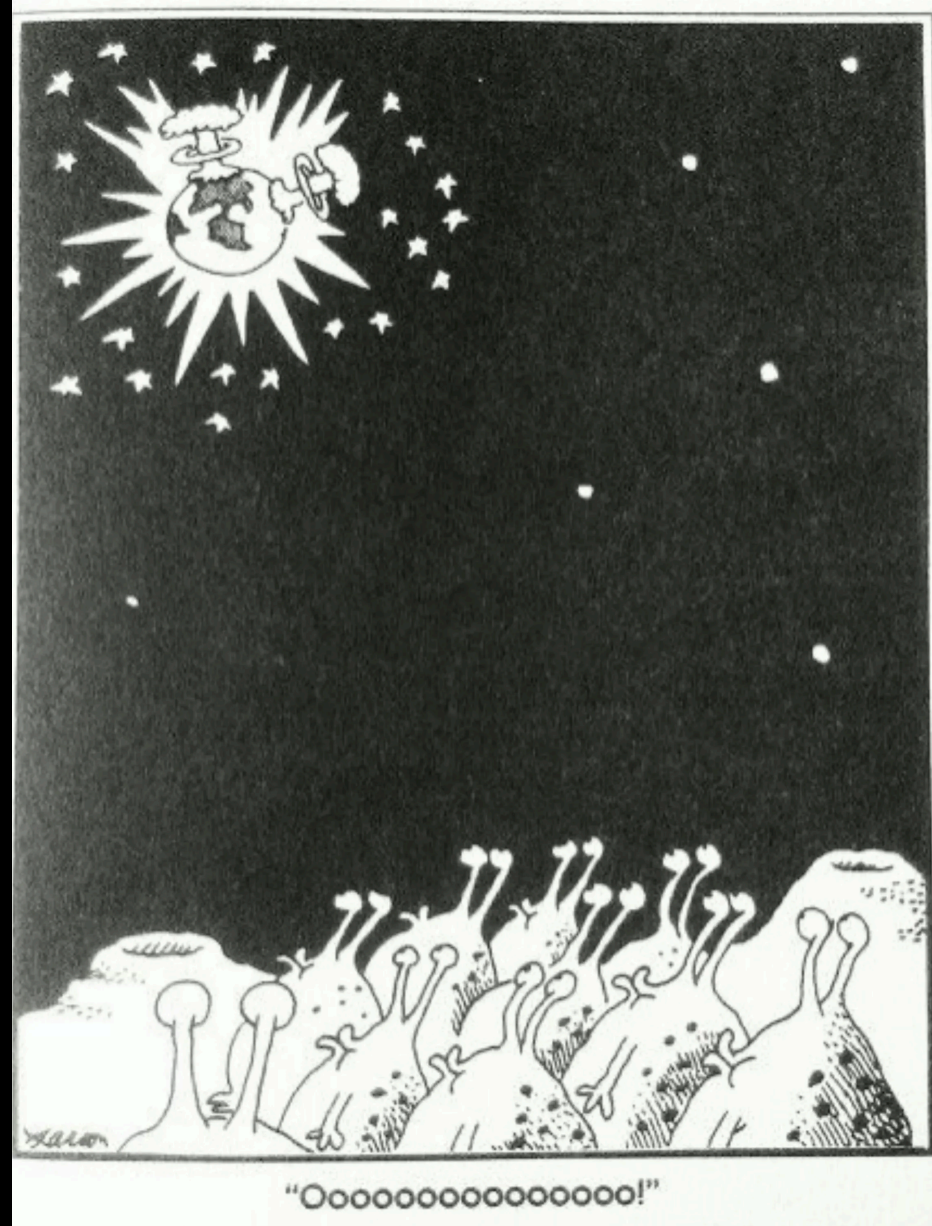
- Galactic Location
- Solar system formation
- Solar activity
- Volatile delivery
- Orbital evolution
- Metallicity
- UV shielding
- Atmospheric composition
- Interior composition
- Plate tectonics
- Mass extinctions
 - Volcanism
- K – Pg boundary



“Heeeeeere, yakity yak yak yak! ...
Come, come, yakity yak yak yak!”

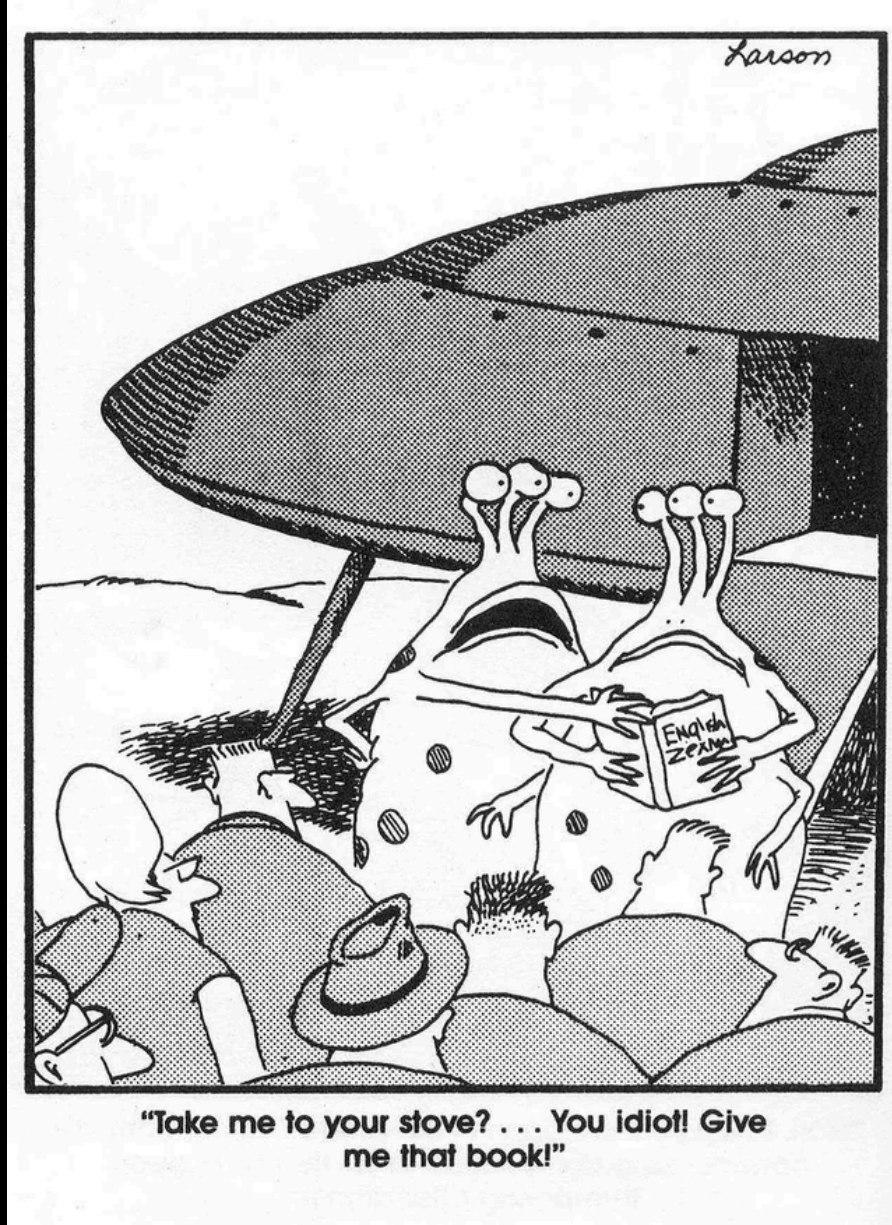
The Great Filter

- Barriers to technological civilization longevity
- Are we one of the luck few – **ONLY** one?



A Universe Primed for Life

- Physical constants
- Periodic table of elements
- A place for life to take hold
- Abiogenesis
- Time



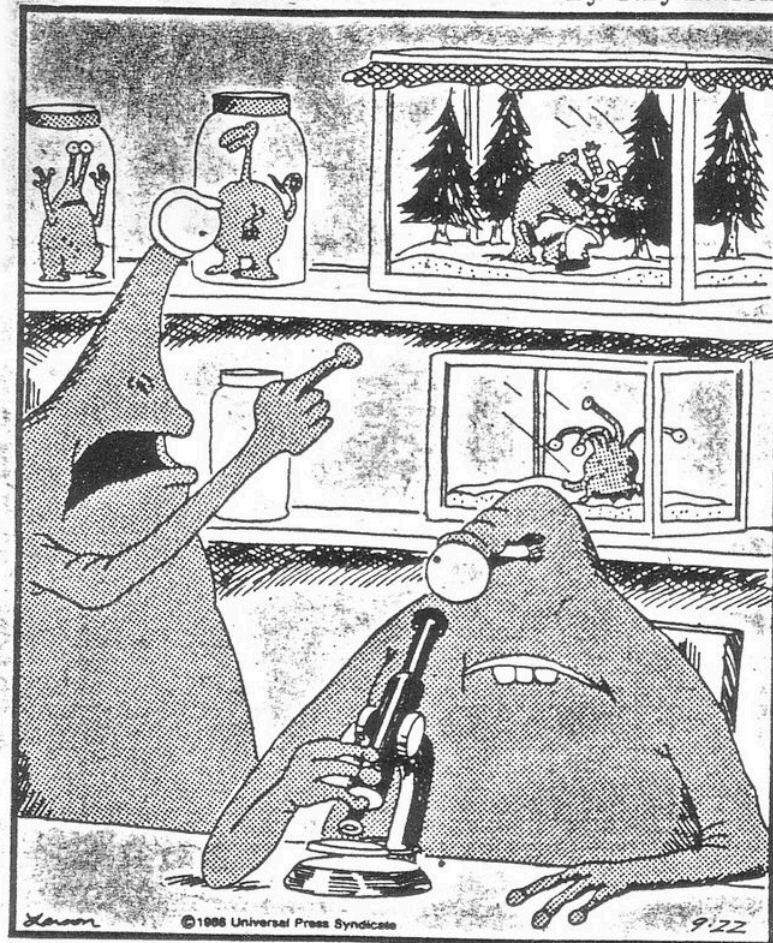
A Change in Direction

- The giggle factor
 - UFOs
 - SETI
- What brought about this change?
- Astrobiology

ay, Sept. 22, 1988

THE FAR SIDE

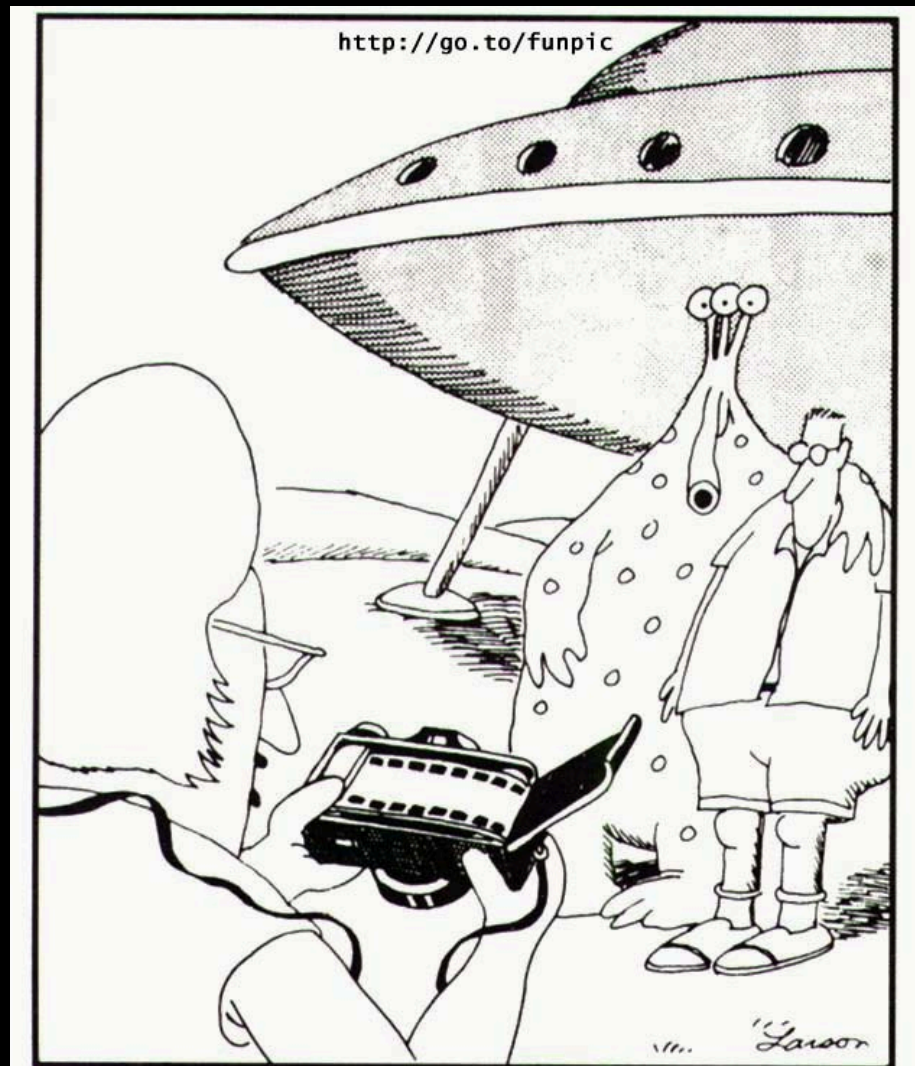
By Gary Larson



"Zorak, you idiot! You've mixed incompatible species in the earth terrarium!"

Exoplanets

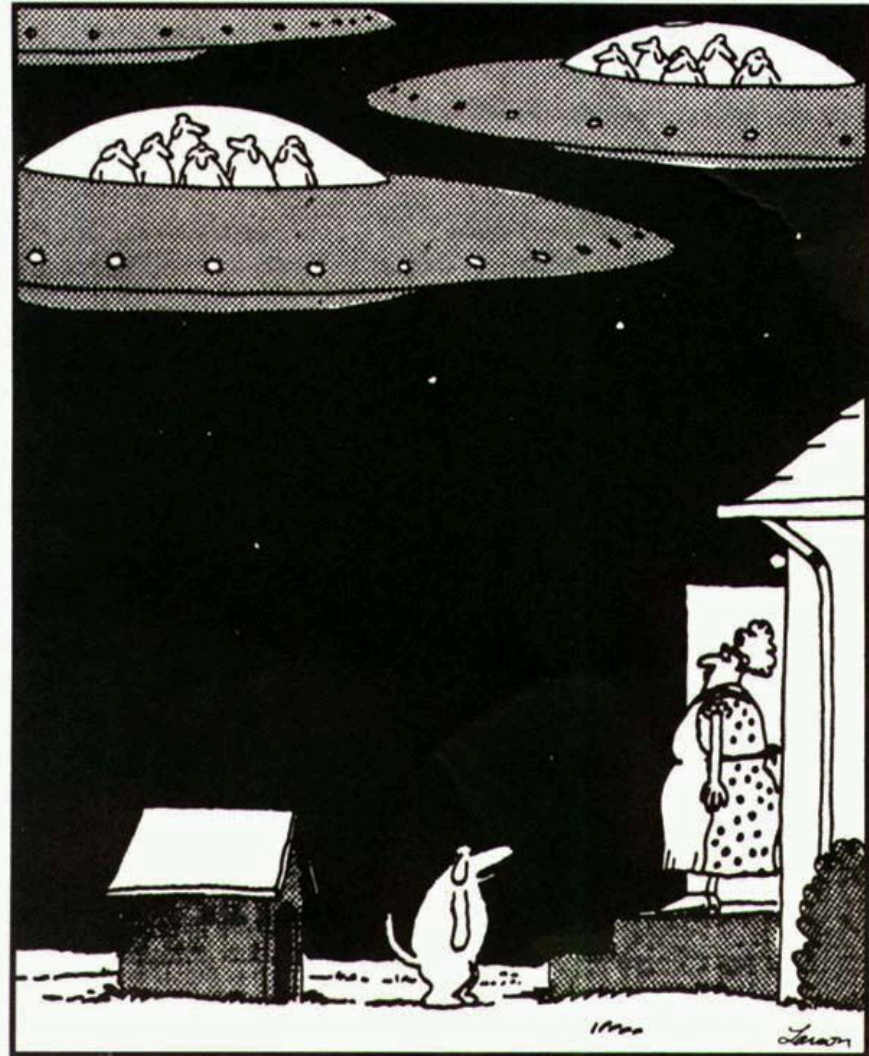
- First exoplanet discovery 1995
- Radial velocity method
- transit method
- Ground based telescopes
- Habitable Zone
- Space telescopes
 - Hubble
 - Kepler
 - TESS
 - Gaia
 - JWST
 - Habitable Worlds
- Where to look?
 - small rocky worlds
 - hycean (water) worlds
 - heat source
 - atmosphere
 - water



"Yes, yes, already, Warren! ... There is film in the camera!"

Atmospheric Modeling

- Characterization of exoplanet atmospheres
- Transit spectroscopy
 - Hubble – water vapour only
 - JWST – H_2O , CO , CO_2 , CH_4 , H_2S

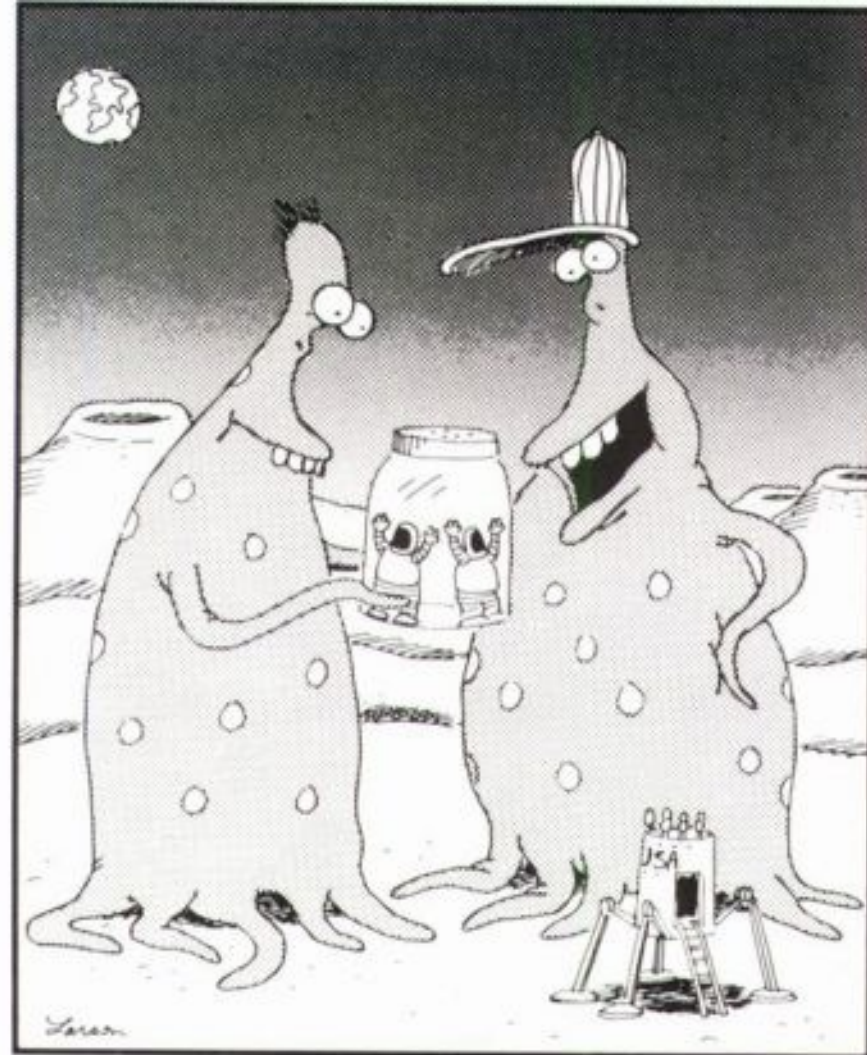


"Well, they finally came. ... But before I go,
let's see you roll over a couple times."

<http://go.to/funpic>

Biosignatures

- How life hijacks and changes atmospheres
- photosynthesis
 - oxygen
- Does habitability = inhabited?
- Does life always evolve complexity over time?

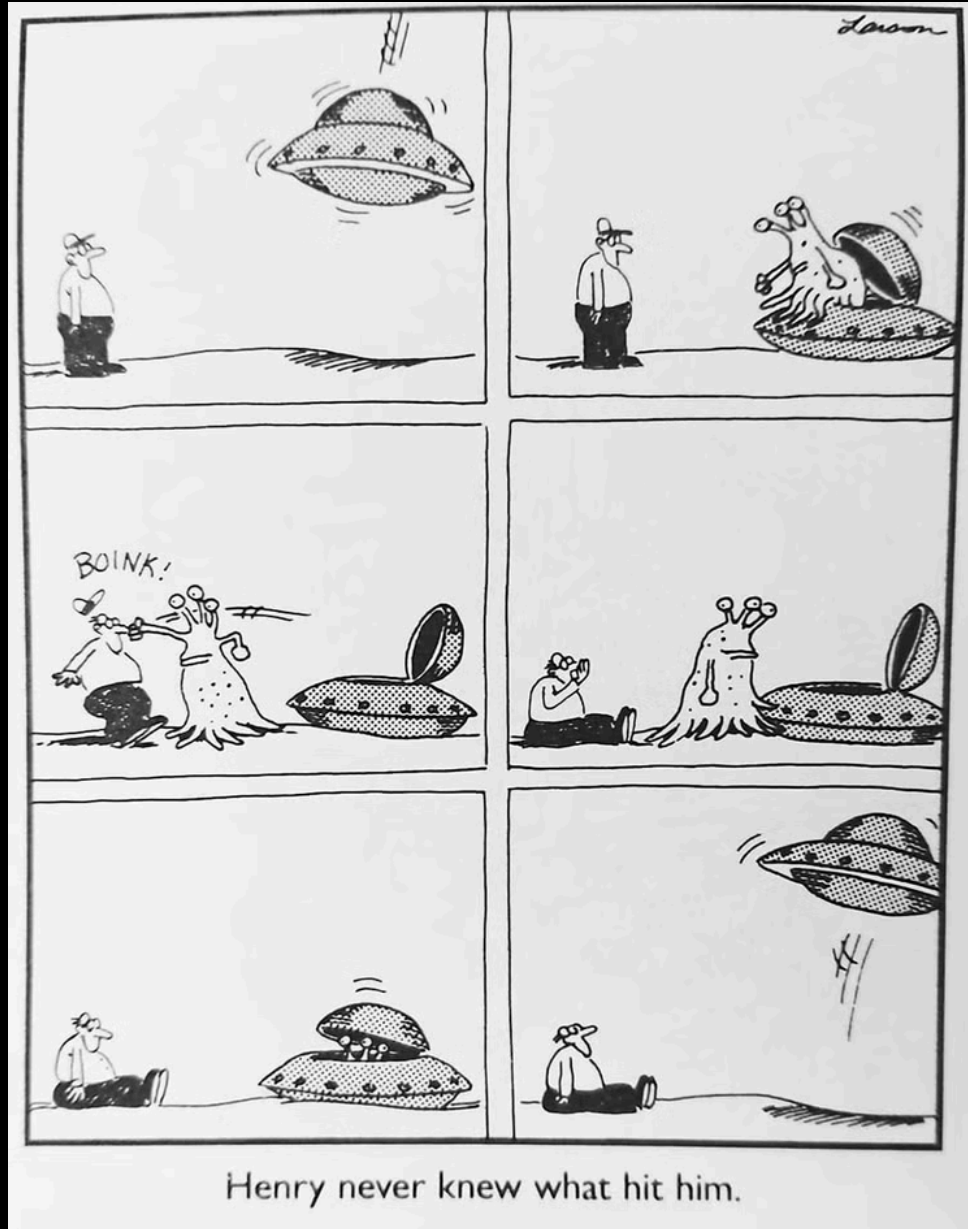


"Pretty cool, Dewey. ... Hey! Shake the jar
and see if they'll fight!"

<http://go.to/funpic>

Technosignatures

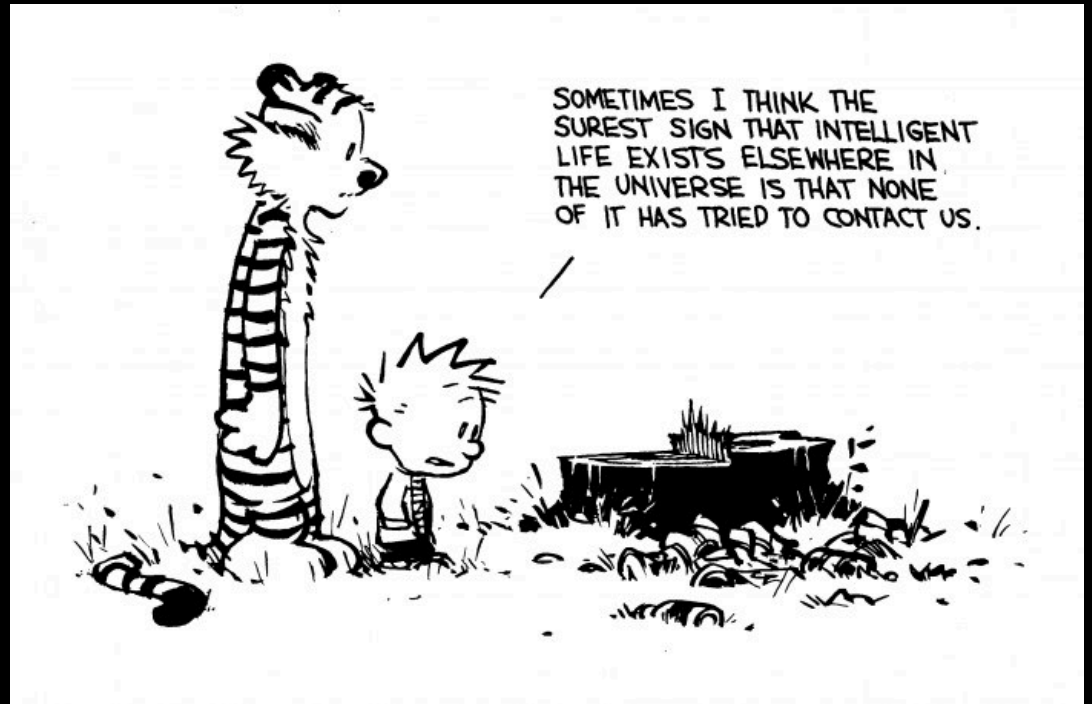
- Technospheres
- pollution
- CFCs



If life is easy we will find it soon.

If it is rare, it will take a long time.

If we do not find evidence for life elsewhere, that does not mean that it does not exist.



Novice Astronomy Class
March 6, 2026
Solar System Series: The Asteroid Belt

NASA / JPL