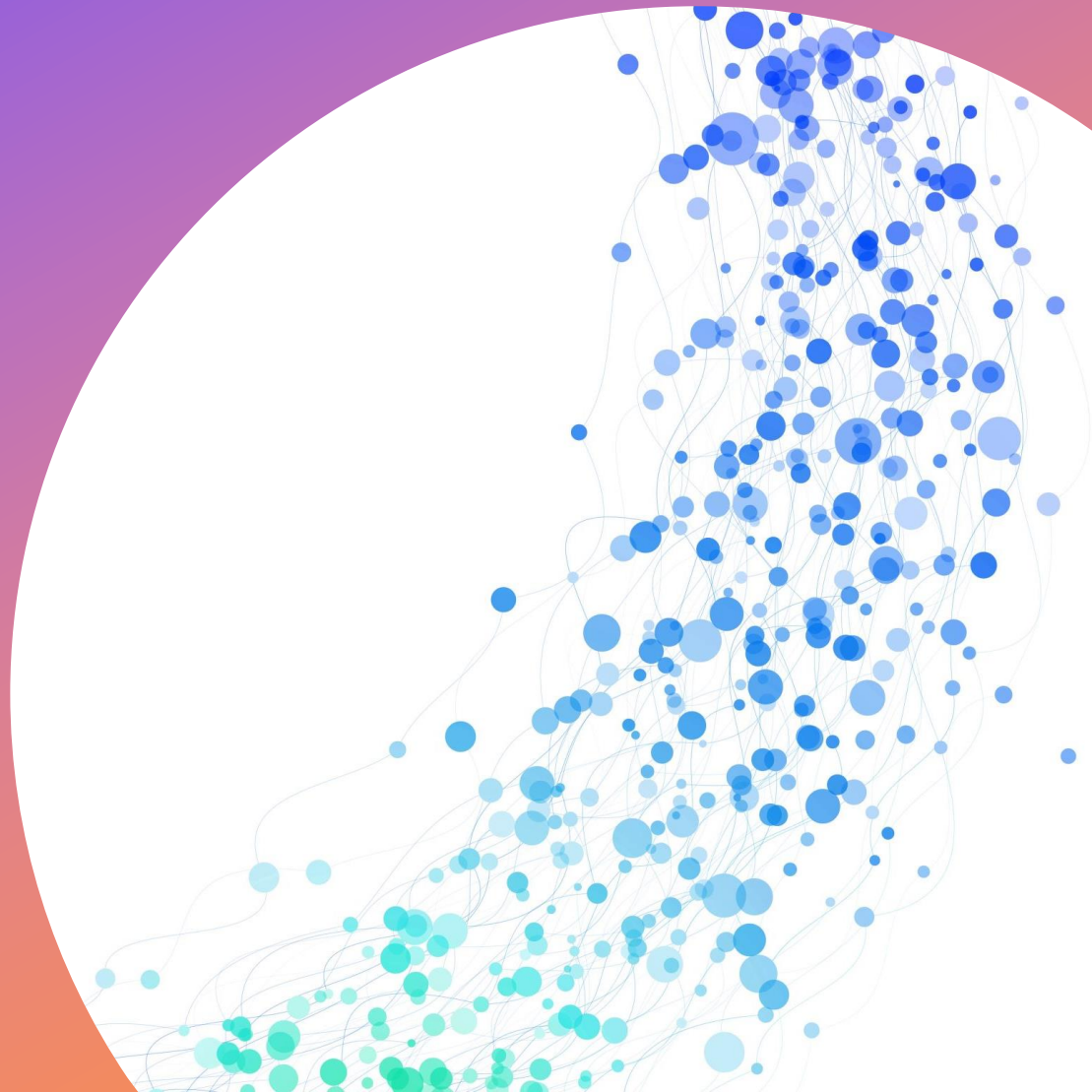
SETI & CHRISTIAN BELIEFS

GC Science

C. David Seuss

September 2021



Topics

- Cultural backdrop
- The argument for extraterrestrial intelligent civilizations
- The Drake Equation
- SETI
- The key questions for the faith
- The Rare Earth Hypothesis
- The probabilities: are we alone?

Questions to keep in mind while considering this presentation

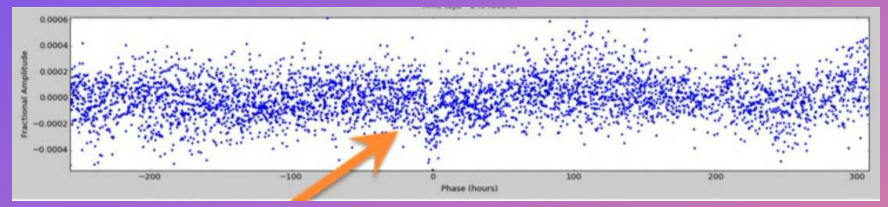
1. Considering all the evidence, do you believe that intelligent alien civilizations probably exist out there somewhere?
   - Why or why not?
2. If you believe that there are, what do you believe are the implications for Original Sin, the Incarnation, the Redemption?
3. If you don't believe there are alien civilizations, and we are here for a purpose, why is there the rest of such a vast Universe?

Americans believe in alien civilizations

A Gallup Poll in July 2021 found that 49% of Americans believe UFOs are of alien origin

A Pew Research study in June 2021 found that 65% of Americans believe there is intelligent life on other planets

NASA uses the possibility of alien life as a business model

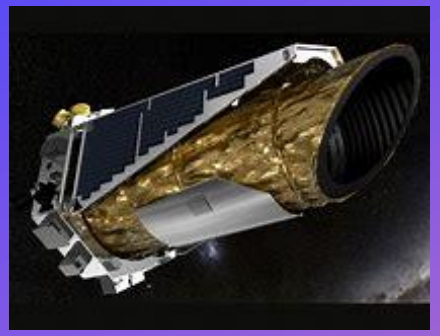


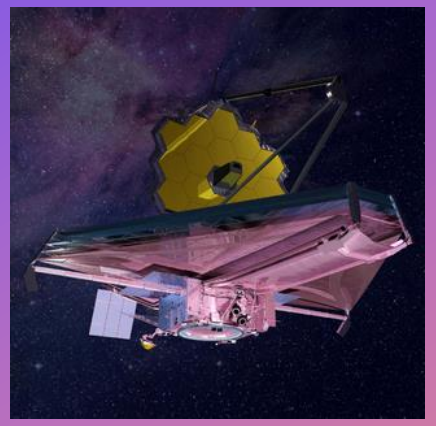
Exoplanet blocking the light from a distant star

In a 2017 TV interview from the ISS, Commander Peggy Whitson and crew members Jack Fischer and Thomas Pesque all agreed that there must be abundant life throughout the Milky Way because of the shear number of stars

Huge amount of effort going into exoplanent detection

The amount of effort and taxpayer dollars going into exoplanet detection is huge





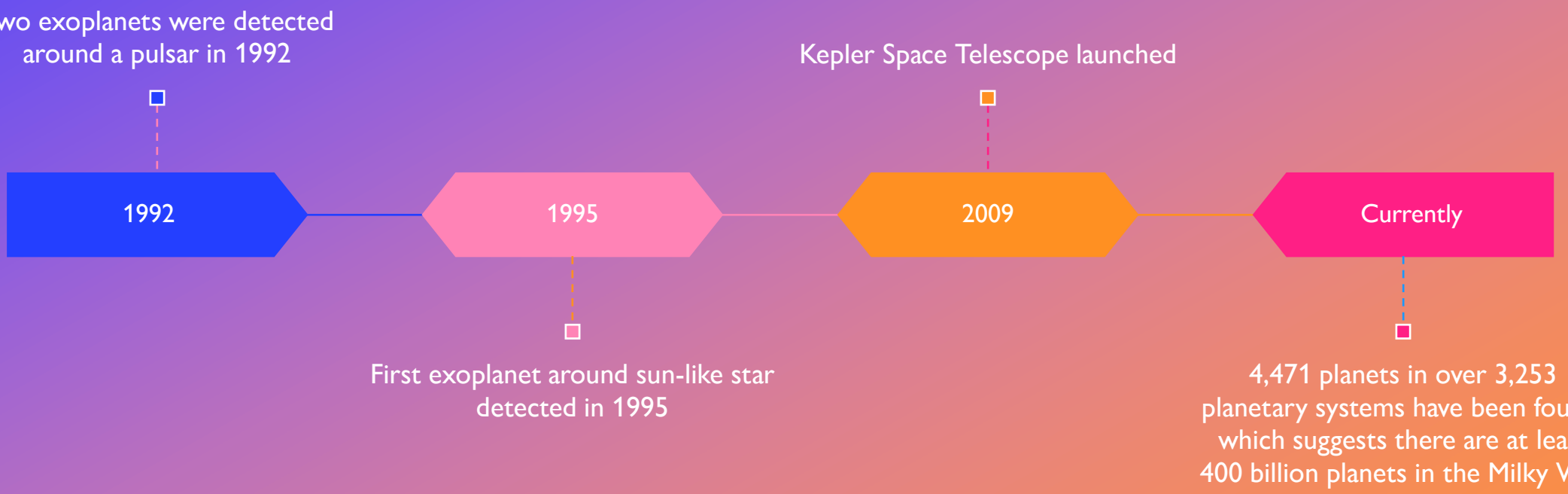
The Kepler Space Telescope launched in 2009 has been responsible for 70% of exoplanet detections so far and uses the transit method

The Transiting Exoplanet Survey Satellite (TESS) launched in 2018 will survey 200,000 of the brightest stars near us to search for transiting exoplanets

The James Webb Space Telescope (JWST or Webb) features a large infrared telescope with a 6.5-meter primary mirror will be launched in December 2021 and will be capable of direct imaging and atmospheric analysis of exoplanets

NASA's chief scientist, Ellen Stofan, predicted in 2015 we would find indications of life beyond Earth in the next 10 to 20 years

The galaxy appears to be filled with exoplanets

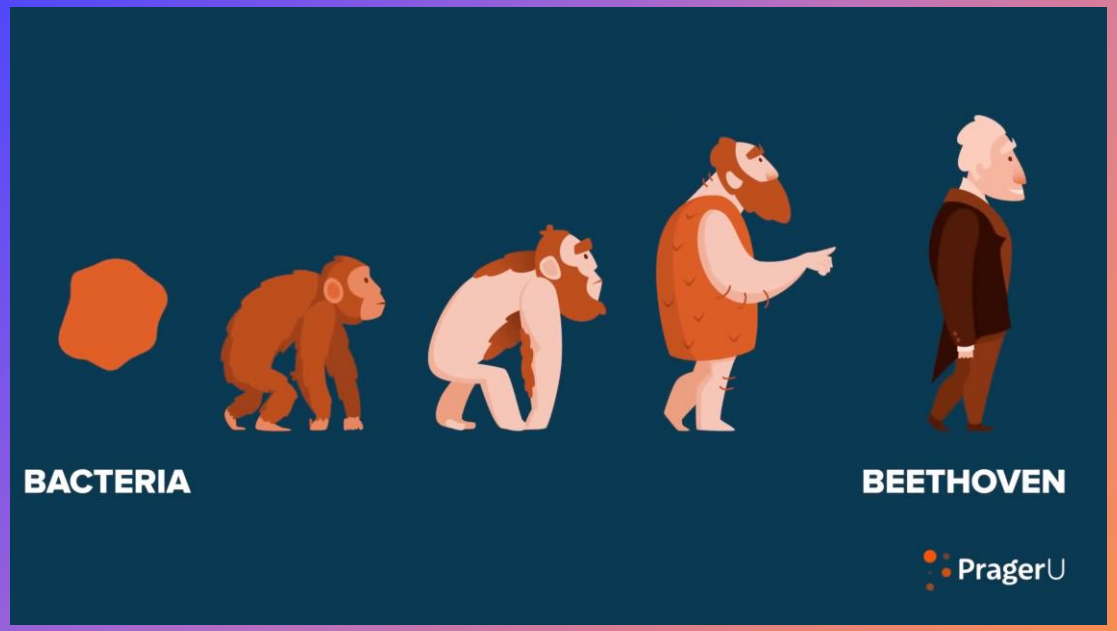


Organic chemicals appear to be ubiquitous in the Universe

Organic chemicals can be produced with simple laboratory experiments such as the Urey Miller experiment in 1952

Organic chemicals have been found in meteorites on Earth, an asteroid, a comet, and in one exoplanet atmosphere

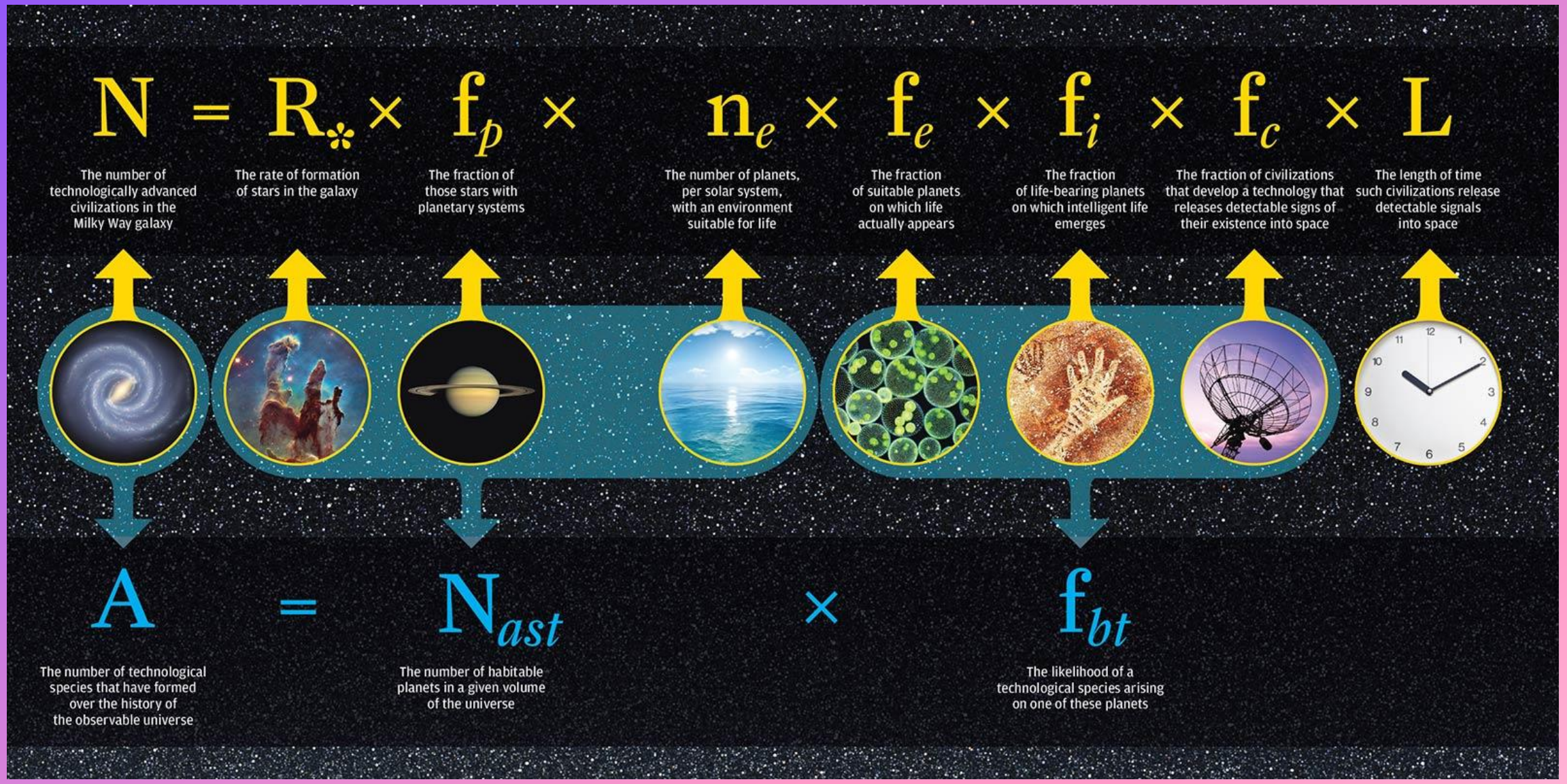
Hypothesis is that if there is opulent production of organic chemicals throughout the Universe which by an unknown process leads to bacterial life everywhere



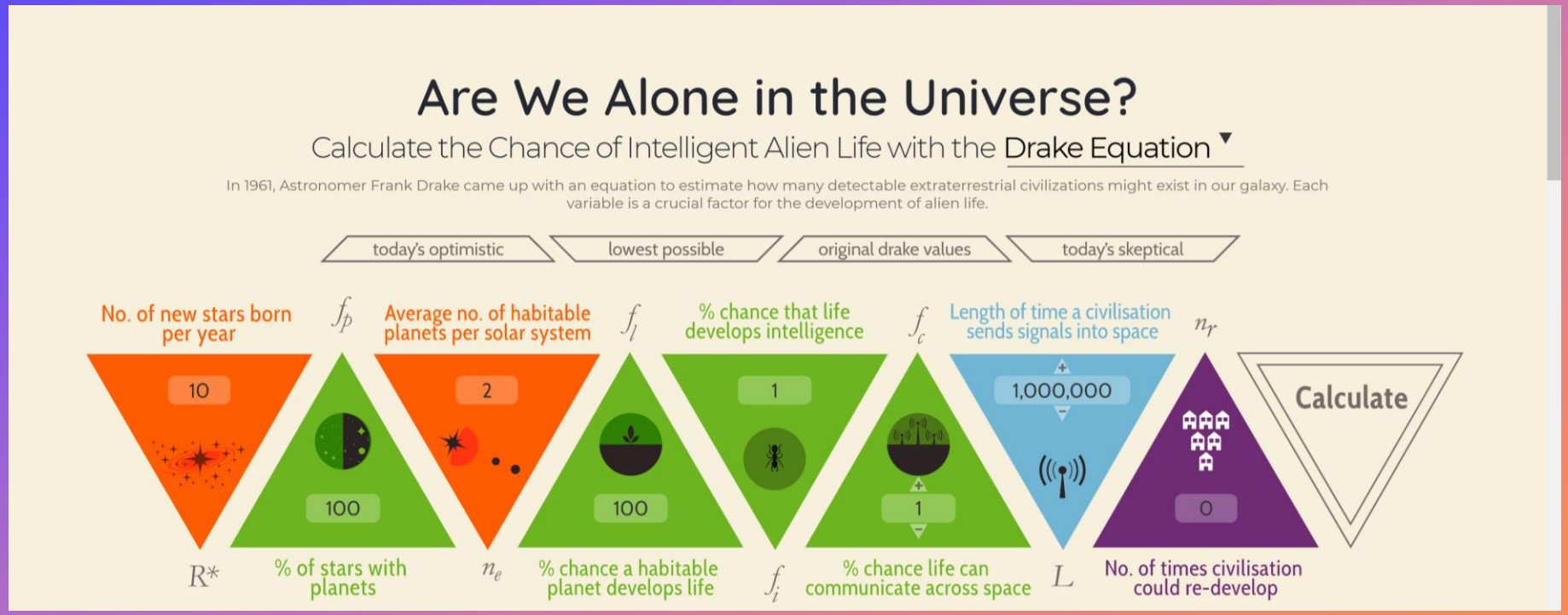
A key assumption: once life starts on a planet, intelligent life is inevitable

- Organic chemicals
- Simple single-cell organisms (Archaea/Bacteria)
- Complex single-cell organisms (Eukaryotes)
- Multi-cell organisms
- Plants
- Animals
- Intelligent civilizations

The Drake Equation from a webpage on NASA.gov



Do your own calculations here of the number of intelligent civilations using the Drake Equation at this website



https://www.informationisbeautiful.net/visualizations/the-drake-equation/

The Astrophysical Journal, 896:58 (18pp), 2020 June 10 https://doi.org/10.3847/1538-4357/ab8225

The Astrobiological Copernican Weak and Strong Limits for Intelligent Life

Tom Westby and Christopher J. Conselice
School of Physics and Astronomy, University of Nottingham, UK
Received 2019 December 4; revised 2020 March 15; accepted 2020 March 17; published 2020 June 15

Abstract

We present a cosmic perspective on the search for life and examine the likely number of Communicating Extra-Terrestrial Intelligent (CETI) civilizations in our Galaxy by utilizing the latest astrophysical information. Our calculation involves Galactic star formation histories, metallicity distributions, and the likelihood of stars hosting Earth-like planets in their habitable zones, under specific assumptions which we describe as the Astrobiological Copernican Weak and Strong conditions. These assumptions are based on the one situation in which intelligent, communicative life is known to exist—on our own planet. This type of life has developed in a metal-rich environment and has taken roughly 5 Gyr to do so. We investigate the possible number of CETI civilizations based on different scenarios. At one extreme is the Weak Astrobiological Copernican scenario—such that a planet forms intelligent life sometime after 5 Gyr, but not earlier. The other is the Strong Astrobiological Copernican scenario in which life must form between 4.5 and 5.5 Gyr, as on Earth. In the Strong scenario (under the strictest set of assumptions), we find there should be at least 36^{+125}_{-35} civilizations within our Galaxy: this is a lower limit, based on the assumption that the average lifetime, L, of a communicating civilization is 100 yr (since we know that our own civilization has had radio communications for this time). If spread uniformly throughout the Galaxy this would imply that the nearest CETI is at most $17{,}000^{+33{,}600}_{-10{,}000}$ lt-yr away and most likely hosted by a low-mass M-dwarf star, likely far surpassing our ability to detect it for the foreseeable future, and making interstellar communication impossible. Furthermore, the likelihood that the host stars for this life are solar-type stars is extremely small and most would have to be M dwarfs, which may not be stable enough to host life over long timescales. We furthermore explore other scenarios and explain the likely number of CETI there are within the Galaxy based on variations of our assumptions.

Unified Astronomy Thesaurus concepts: Astrobiology (74); Astrostatistics (1882); Milky Way Galaxy (1054); Metallicity (1031); Stellar abundances (1577); Star formation (1569); Habitable planets (695); Exoplanet astronomy (486); Exoplanets (498)

1. Introduction

One of the oldest questions that humans have asked is whether our existence—as an advanced intelligent species—is unique. While this question can be divided up into many separate problems and tangents, the main issue, in modern terminology, is whether there are other intelligent species somewhere in the visible universe. Furthermore, this has often been framed as a question of whether there are intelligent life-forms that we, in principle, could communicate within our own Galaxy. The focus on our own Galaxy is due largely to the likely infeasibility at present of finding communication signals from more distant stellar systems, such as external galaxies.

Of course, from a statistical perspective, this is one of the most challenging problems in science, since all we can do is attempt to learn from a single known data point (ourselves), with no possible method of modeling the distribution of the potential population of civilizations across the Galaxy. The process of this attempted extrapolation from $N = 1$, with no knowledge of a sample mean or standard deviation, would seem to push the integrity of logic to its limits. As Ball (2005) states, in his critique of the analysis of Gott (1993) on the "Implications of the Copernican Principle into our future prospects," many authors argue that "Gott had spun phantom knowledge from complete ignorance… the basic flaw lies in assigning equal probabilities to events about which we know nothing." Therefore, inevitably, the subject of extraterrestrial intelligent and communicative civilizations will remain entirely in the domain of hypothesis until any positive detection is made, but this does not necessarily mean that we cannot propose models, based on sound logical assumptions, that may at least produce plausible estimates of the occurrence rate of such civilizations—if nothing else, we may be able to assess the likelihood of our own existence being unique, or whether the Search for Extra-Terrestrial Intelligence (SETI) is ever likely to bear fruit. Furthermore, when SETI succeeds there are implications for the uniqueness of our own civilization on Earth and our study is a reference frame for this perspective.

This issue is of monumental importance and interest to humanity but has of yet no answer, or even good guesses. There is a long history of these searches, starting with efforts by, e.g., Cocconi & Morrison (1959), who searched for signals from extraterrestrial intelligence without success. Searches have been greatly extended since and have been ongoing for the past few decades but still without any reliable detections, although the search area is still very small (Wright et al. 2018). Most famously, Drake (1965) developed an equation which in principle can be used to calculate how many Communicating Extra-Terrestrial Intelligent (CETI: pronounced "chetee") civilizations there may be in the Galaxy. However, many of its terms are unknowable and other methods must be used to calculate the likely number of communicating civilizations.

Due to advances in astrophysics and knowledge of star formation and planetary systems we are collecting enough data to enable a new examination of the occurrence rate of CETI in the Milky Way. With new and better data on our Galaxy's star formation history and a better knowledge of the characteristics of exoplanets, we can now make a solid attempt to answer the

Question: According to modern estimates of the Drake Equation, how many alien civilizations are out there?

In the "The Astrobiological Copernican Weak and Strong Limits for Intelligent Life" published in the Astrophysical Journal, June 2020," Tom Westby and Christopher Conselice of the University of Nottingham updated the Drake Equation estimates

The authors define a communicating extraterrestrial intelligent (CETI) civilization as one that has radio communications

Key adjustments to the Darke Equation

- Adjust for metallic content of the star (star type and galactic position)
- Adjust for stellar lifetime based on star type

Westby's and Conselice's Results: there are between 36 and 13,080 CETIs in the Milky Way, and almost all of them are around M dwarf stars

Assumption	Approximate Number of CETIs	Expected Distance to Nearest From Earth
Life forms during stellar ages 4.5B – 5.5B years old; CETI lasts 100 years	36	17,000 Light Years
Life forms anytime during 4B-6B years; CETI lasts 2,000 years	~212	~3,700 Light Years
Life forms anytime after stellar age > 5B and lasts for lifetime of the star; CETI lasts 1,000,000 years	~13,080	~160 Light Years

Summarizing the argument for the existence of extraterrestrial intelligent civilizations

- There are 400 billion stars in the Milky Way
- Most of them have planets
- Organic chemicals are ubiquitous
- Life forms wherever organic chemicals are found
- Intelligent life develops inevitably from primitive life
- So they have to be out there

SETI 50 years in

All together, there were a few thousand stars surveyed before 2017, including some “local” targets

Plans of the SETI Institute related projects expect to expand this to one million stars over the next 20 years (due to the Allen Array)

Focus will be also on a few thousand stars with discovered exoplanets, with special interest in the TRAPPIST-1 group, and those with organic compounds in the atmosphere as determined by the James Web Space Telescope (JWST)

Curtin University effort surveyed one million stars with a comprehensive approach to frequencies

Breakthrough Listen has surveyed 60 million stars in the direction of the galactic center looking for a particular pattern of on-again, off-again transmission

Defenders of SETI point out that only a tiny fraction of the Milky Way’s 400 billion stars have been surveyed - and they need to defend it because so far …

… nothing but silence

"Will the now widely accepted hypothesis of highly developed sentient life throughout the stellar universe affect religious creeds?"

- Harvard Astronomer Harlow Shapley, 1960

The existence of extraterrestrials does not appear on the surface appear to be a problem for Islam, Judaism, Buddhism, or Hinduism

But extraterrestrial intelligent beings may pose special questions for Christians …

If other planets have intelligent beings around them, what are we to make of the Biblical tradition that Earth is a special place in the eyes of God?

ARISTOTLE HAD EARTH AS THE CENTER OF THE UNIVERSE

EVER SINCE NICHOLAS COPERNICUS PUT EARTH IN ORBIT AROUND THE SUN EARTH HAS BEEN TRIVIALIZED

THERE IS EVEN A NAME FOR THIS: THE PRINCIPLE OF MEDIOCRACY

"The human race is just a chemical scum on a moderate-sized planet, orbiting around a very average star in the outer suburb of one among a hundred billion galaxies. We are so insignificant that I can't believe the whole universe exists for our benefit." - Stephen Hawking in a 1995 TV Interview

Does the original sin of Adam apply to extraterrestrials?

Do extraterrestrial aliens have original sin? … I have difficulties with the notion of original sin. However, if such beings do exist, and if they are subject to death and are capable of evil, they will need some sort of redemption. - Peter Berger, 2011

Knowledge of extraterrestrials would help us penetrate the wisdom of the plans of God and the evil of sin. If they live in a state of justice, they would not have committed original sin, and we would see the immensity of all that was lost by our ancestors through sin. In the case of a redemption like ours we would see the special love of God for us in terms of a further experience of this love. - Domenico Grasso, 1952

How are we to think of the incarnation of God as Jesus in human form if there are other intelligent beings on other planets?

When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou has ordained; What is man, that thou are mindful of him? And the son of man, that thou visited him? - Psalm 8 KJV

The hypothesis of a special revelation, in some millions of centuries to come, teaching the inhabitants of the system of Andromeda that the Word was incarnate on Earth is just ridiculous. - Teilhard de Chardin, 1971

How to understand the meaning of the symbol 'Christ' in the light of the immensity of the Universe . . . … Incarnation is unique for the special group in which it happens, but it is not unique in the sense that other singular incarnations for other unique worlds are excluded..
- Paull Tillich, 1953

Did Jesus die for their sins too?

As to the question whether Christ by dying on this Earth could redeem the inhabitants of another world, I answer that he was able to do this even if the world were infinite, but it would not be fitting for Him to go unto another world that he must die again. – William of Vorilong, 1450

The hypothesis of a special revelation, in some millions of centuries to come, teaching the inhabitants of the system of Andromeda that the Word was incarnate on Earth is just ridiculous. All that I can entertain is the possibility of a multi-aspect Redemption which would be realized on all the stars. - Teilhard de Chardin, 1971

Hmmm… many believers today aren't that worried

In a 2011 survey of 1300 people, Ted Peters asked whether they thought the discovery of extraterrestrial intelligence would shake their individual belief of the strength of their religion as a whole

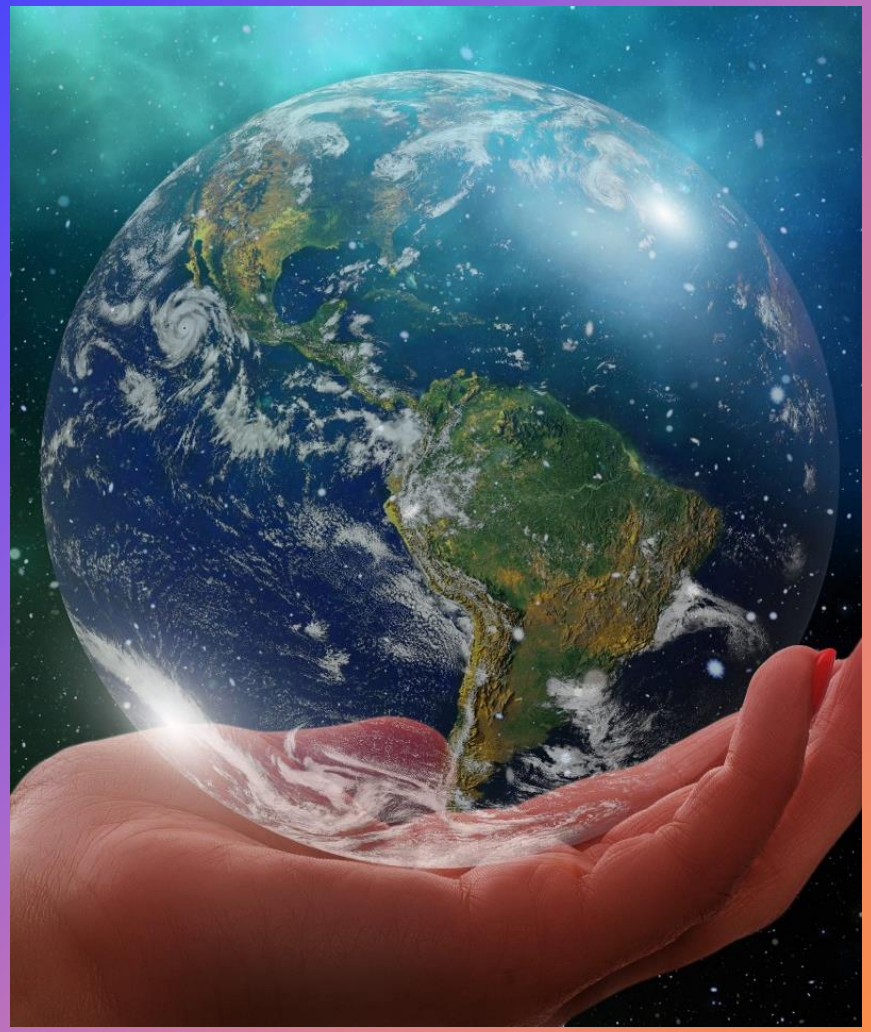
The conclusion was across the different religious traditions (Roman Catholics, evangelical Protestants, mainline Protestants, Mormons, Jews, and Buddhists) the vast majority of believers see no threat to their personal beliefs

There was some concern that their religious leaders might face a challenge, but there was overwhelming confidence that their tradition would not collapse

This contrasted with those who identified themselves as non-religious, of which 69% thought the discovery would cause a crises for world religions

But not so fast

I am as prepared for the arrival of extra-terrestrials as I am for that of elves, and for the same reason: All evidence points to their non-existence, and yet it remains a very, very remote possibility—so remote that to change our central doctrines to accommodate either possibility would be folly. (Benjamin Wiker, 2002)



The Rare Earth Hypothesis

Rare Earth, Why Complex Life is Uncommon in the Universe by Peter Ward and Donald Brownlee in 2000 mounts an all-out attack on the Drake Equation

Ward is a professor of geology and Brownlee is a professor of Astronomy at the University of Washington in Seattle

They lay out a case for why we may be the only intelligent civilization in the galaxy

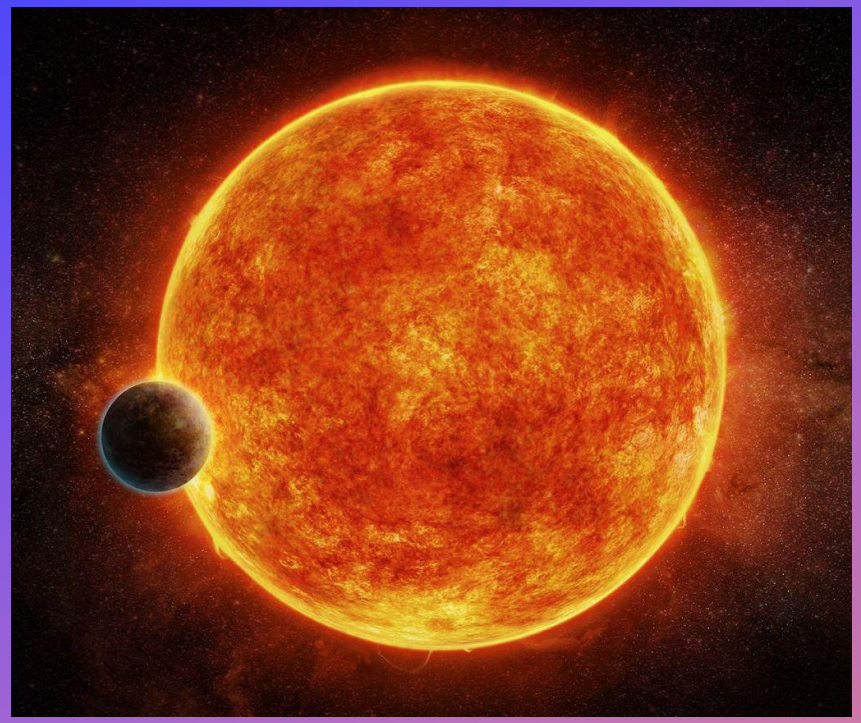
400 billion stars in the Milky Way – but not many of them could support complex life

- Globular clusters: metal poor, solar-mass stars too large and hot, stellar encounters
- Center of galaxy: too much radiated energy, stellar encounters
- Edge of galaxy: most stars are metal poor
- Planetary systems with “hot Jupiters:” drives inner planets into their star
- Planetary systems with giant planets in eccentric orbit:s disturbs orbits of rocky inner planets

Rare Earth factors required to support evolution of complex life

- Right distance from star to have liquid water, avoid tidal lock
- Right mass of the star; right age of the star (4.5 billion years)
- Stable planetary orbits
- Right planetary mass, retain atmosphere, molten core
- Jupiter-like neighbor with stable orbit
- Plate tectonics to build up land mass, enhance biotic diversity, enable magnetic field
- Ocean: not too much, not too little
- Large moon, right distance to stabilize tilt
- Right planetary tilt
- No sterilizing impacts after a certain period
- Right amount of carbon; not too much, not too little
- Right atmospheric properties
- Successful evolutionary pathway to complex plants and animals
- Evolution of oxygen (photosynthesis at just the right time)
- Right position in the galaxy: not in center or the edge, not in a spiral arm (5-10% of stars)

M dwarf stars, by far the most common in the Milky Way, are thought by many to be hostile to life



The picture is to scale of an Earth-sized planet orbiting very close in the habitable zone of the M dwarf star in a tidally locked orbit.

- Small, dim, cool with a stellar life of 10 trillion years
- Cool temperature means the habitable zone is very close to the star
- Close orbit means the planet will be tidal locked with the star and turn the same face toward the star all the time
- One side raging hot, the other side deeply frozen
- Cannot support any known model of life, even primitive life, hard to imagine how complex life could develop

The Rare Earth Equation

The Drake Equation

$N = R^* \times Fp \times Ne \times Fe \times Fi \times Fc \times L$

The Rare Earth Equation

$N=R^* \times Fp \times Fpm \times Ne \times Ng \times Fi \times Fc \times Fl \times Fm \times Fj \times Fme$

Key to the equations

- N = number of with ETI
- R*= rate of star formation in the Milky Way (Drake) or number of stars in the Universe
- Fp = fraction of stars with planets
- Fpm = fraction of metal rich planets
- Ne = planets in a star's habitable zone
- Ng = stars in the galactic habitual zone
- Fi = fraction of habitable planets where life does arise (Fe in the Drake Equation)
- Fc = fraction of planets with life where complex animals arise
- Fl = percentage of a plant's lifetimes marked by the present of complex animals
- Fm = fraction of planets with a large moon
- Fj = fraction of solar systems with Jupitar-sized planets
- Fme = fraction of planets with a critically low number of mass extinction events
- L = the number of years an advanced civilization survives (Drake Equation only)

Brownlee and Ward's conclusion

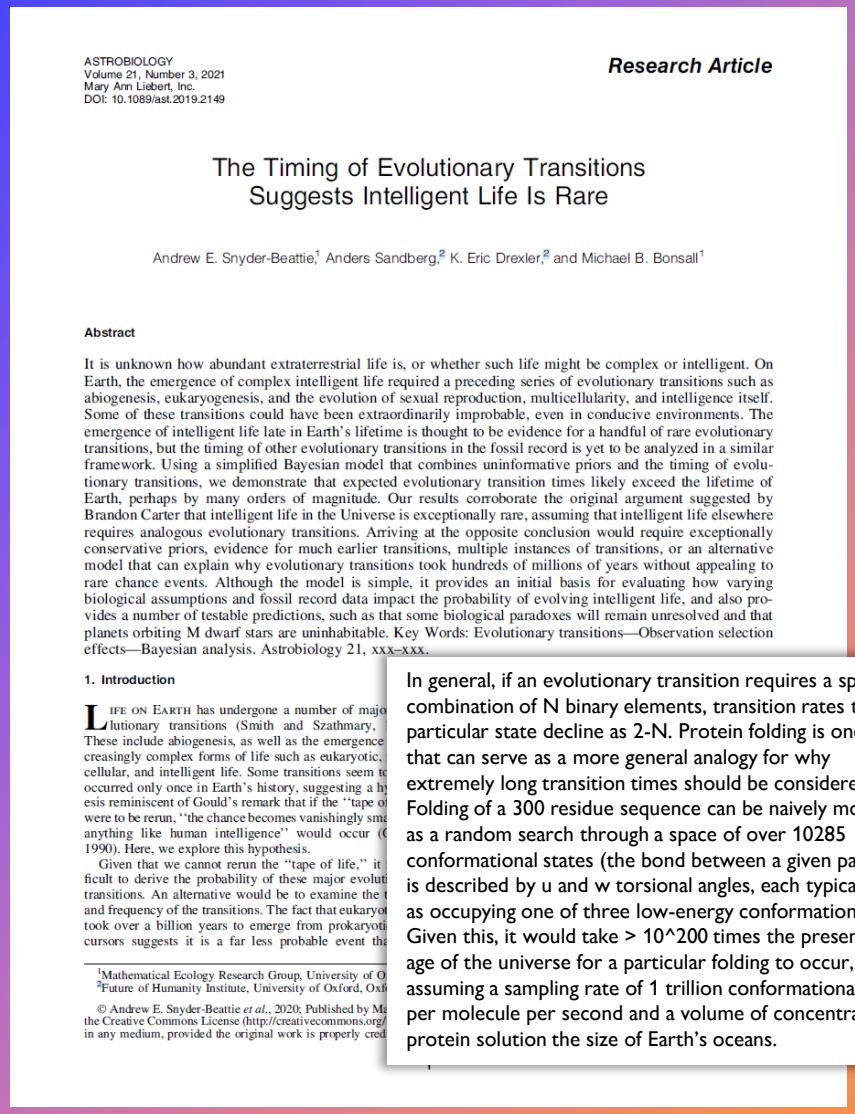
"Again, as any term in such an equation approaches zero, so too does the final product.

How much stock can we put in such a calculation? Clearly, many of these items are known only in the sketchiest detail…But it is our contention that any strong signal can be perceived even when only sparse data are available.

To us, the signal is so strong that even at this time, it appears that Earth indeed may be extraordinarily rare."

Hugh Ross discusses addtional factors in his book *Improbable Planet* that, combined with Brownlee and Ward's revised Rare Earth Equation, make it even less probable that there are other locations in the Milky Way that could support life

- Star with very little luminosity variance
- Red dwarfs, white dwarfs, red giants, hot stars, Cepheid Variables all have conditions that would prevent complex life (only 9% of stars have the right size, temperature, etc., to support complex life)
- Binary stars: unstable heating and cooling
- Solar System born in a globular cluster with four near concurrent supernovas ejecting highly unusual amounts of heavy metals into the Sun's gravitational well – followed by an exit outward, followed by a stabilization of the outward trajectory just short of the galactic Co-Rotation Radius
- Orbit around the Milky Way that oscillates less in the vertical plane (228 light years vs. an average of 400 light years) avoiding the radiation extremes a normal oscillation would incur



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Research Article

The Timing of Evolutionary Transitions
Suggests Intelligent Life Is Rare

Andrew E. Snyder-Beattie,[1] Anders Sandberg,[2] K. Eric Drexler,[2] and Michael B. Bonsall[1]

Abstract

It is unknown how abundant extraterrestrial life is, or whether such life might be complex or intelligent. On Earth, the emergence of complex intelligent life required a preceding series of evolutionary transitions such as abiogenesis, eukaryogenesis, and the evolution of sexual reproduction, multicellularity, and intelligence itself. Some of these transitions could have been extraordinarily improbable, even in conducive environments. The emergence of intelligent life late in Earth's lifetime is thought to be evidence for a handful of rare evolutionary transitions, but the timing of other evolutionary transitions in the fossil record is yet to be analyzed in a similar framework. Using a simplified Bayesian model that combines uninformative priors and the timing of evolutionary transitions, we demonstrate that expected evolutionary transition times likely exceed the lifetime of Earth, perhaps by many orders of magnitude. Our results corroborate the original argument suggested by Brandon Carter that intelligent life in the Universe is exceptionally rare, assuming that intelligent life elsewhere requires analogous evolutionary transitions. Arriving at the opposite conclusion would require exceptionally conservative priors, evidence for much earlier transitions, multiple instances of transitions, or an alternative model that can explain why evolutionary transitions took hundreds of millions of years without appealing to rare chance events. Although the model is simple, it provides an initial basis for evaluating how varying biological assumptions and fossil record data impact the probability of evolving intelligent life, and also provides a number of testable predictions, such as that some biological paradoxes will remain unresolved and that planets orbiting M dwarf stars are uninhabitable. Key Words: Evolutionary transitions—Observation selection effects—Bayesian analysis. Astrobiology 21, xxx–xxx.

1. Introduction

Life on Earth has undergone a number of major evolutionary transitions (Smith and Szathmary, These include abiogenesis, as well as the emergence creasingly complex forms of life such as eukaryotic, cellular, and intelligent life. Some transitions seem to occurred only once in Earth's history, suggesting a hy esis reminiscent of Gould's remark that if the "tape of were to be rerun, "the chance becomes vanishingly sma anything like human intelligence" would occur (G 1990). Here, we explore this hypothesis.

Given that we cannot rerun the "tape of life," it ficult to derive the probability of these major evoluti transitions. An alternative would be to examine the t and frequency of the transitions. The fact that eukaryot took over a billion years to emerge from prokaryoti cursors suggests it is a far less probable event tha

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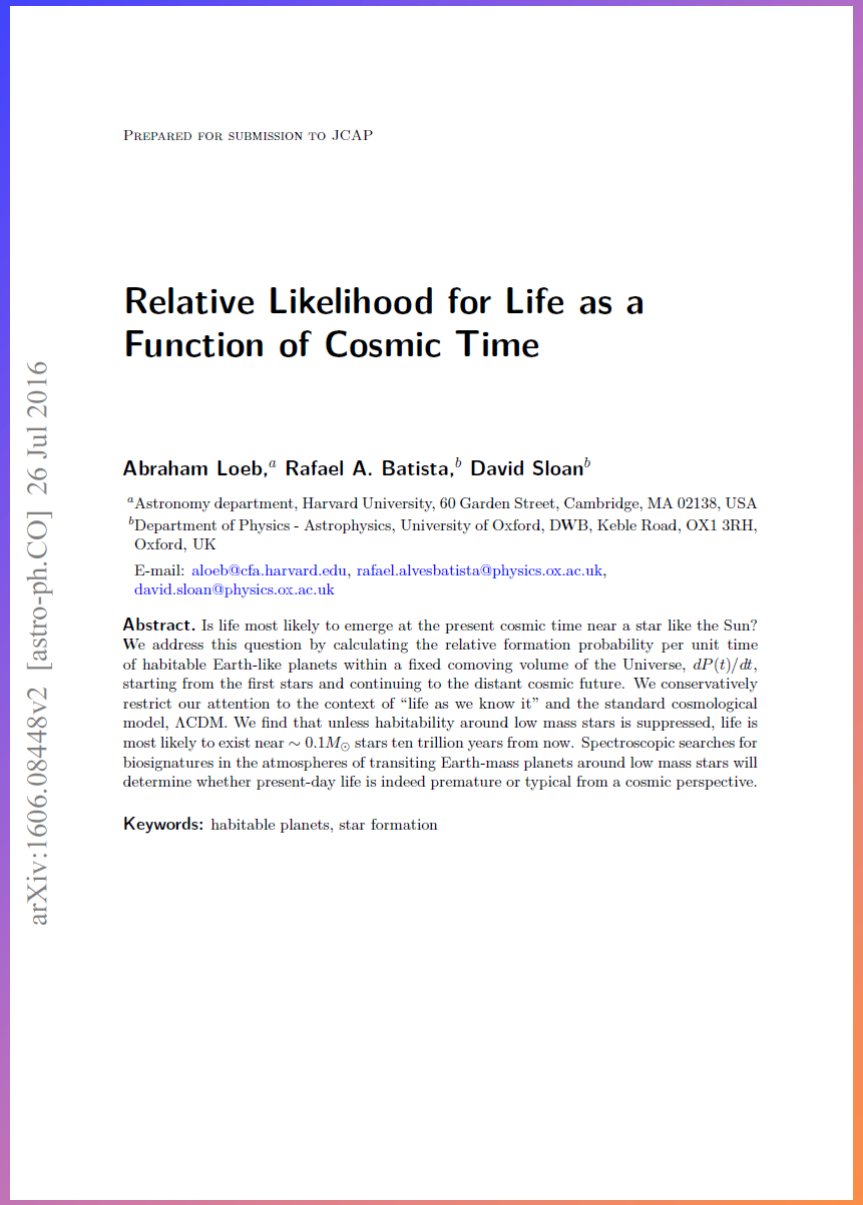
In general, if an evolutionary transition requires a specific combination of N binary elements, transition rates to any particular state decline as 2-N. Protein folding is one example that can serve as a more general analogy for why extremely long transition times should be considered. Folding of a 300 residue sequence can be naively modeled as a random search through a space of over 10285 conformational states (the bond between a given pair of residue is described by u and w torsional angles, each typically regarded as occupying one of three low-energy conformations). Given this, it would take > 10^200 times the present age of the universe for a particular folding to occur, even assuming a sampling rate of 1 trillion conformational states per molecule per second and a volume of concentrated protein solution the size of Earth's oceans.

The Timing of Evolutionary Transitions Suggests Intelligent Life Is Rare

Published in 2021 in *Astrobiology,* by researchers Andrew E. Snyder-Beattie, Anders Sandberg, and K. Eric Drexler - all of the University of Oxford

It took approximately 4.5 billion years for a series of evolutionary transitions resulting in intelligent life to unfold on Earth. In another billion years, the increasing luminosity of the Sun will make Earth uninhabitable for complex life. Intelligence therefore emerged late in Earth's lifetime.

> "We demonstrate that expected transition times likely exceed the lifetime of Earth, perhaps by many orders of magnitude…In turn, this suggests that intelligent life is likely to be exceptionally rare. **…**The model provides a number of other testable predictions, including that M dwarf stars are uninhabitable, that many biological paradoxes will remain unsolved without allowing for extremely unlikely events ..."



Prepared for submission to JCAP

Relative Likelihood for Life as a Function of Cosmic Time

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Abstract. Is life most likely to emerge at the present cosmic time near a star like the Sun? We address this question by calculating the relative formation probability per unit time of habitable Earth-like planets within a fixed comoving volume of the Universe, $dP(t)/dt$, starting from the first stars and continuing to the distant cosmic future. We conservatively restrict our attention to the context of "life as we know it" and the standard cosmological model, ΛCDM. We find that unless habitability around low mass stars is suppressed, life is most likely to exist near $\sim 0.1 M_{\odot}$ stars ten trillion years from now. Spectroscopic searches for biosignatures in the atmospheres of transiting Earth-mass planets around low mass stars will determine whether present-day life is indeed premature or typical from a cosmic perspective.

Keywords: habitable planets, star formation

Relative Likelihood for Life as a Function of Cosmic Time

Published in 2016 in *Journal of Cosmology and Astroparticle Physics* by researchers Abraham Loeb of Harvard and Rafael Batista and David Sloan of the University of Oxford

"Is life most likely to emerge at the present cosmic time near a star like the Sun? We address this question by calculating the relative formation probability per unit time of habitable Earth-like planets within a fixed comoving volume of the Universe, dP(t)/dt, starting from the first stars and continuing to the distant cosmic future. We conservatively restrict our attention to the context of "life as we know it" and the standard cosmological model, CDM …

We find that unless habitability around low mass stars is suppressed, **life is most likely to exist near 0.1M stars ten trillion years from now."** [Emphasis added.]

Should we worry too much about the theological implications of extraterrestrial intelligent civilizations?

Maybe not

The extraordinary circumstances of planet Earth suggest it is rare indeed

The math of the Rare Earth Equation, especially considering supporting research and additional adjustments from factors not incorporated into it, easily supports a scientifically sound proposition that we are most probably the only intelligent beings in the Milky Way

These extraordinary circumstances include our position in space and time in the galaxy, the unusual composition of heavy metals in our solar system, the special characteristics of our Sun, the size of the Moon, the emergence of eukaryotes, etc. etc. etc.

Even the Drake Equation when adjusted for the hostility of the prevalent M dwarf stars and the rarity of evolutionary breakthroughs suggests the same

So, are we alone? [Your answer here.]

Discussion

1. Considering all the evidence, do you believe that intelligent alien civilizations probably exist out there somewhere?
   - Why or why not?
2. If you believe that there are, what do you believe are the implications for Original Sin, the Incarnation, the Redemption?
3. If you don't believe there are alien civilizations, and we are here for a purpose, why is there the rest of such a vast Universe?