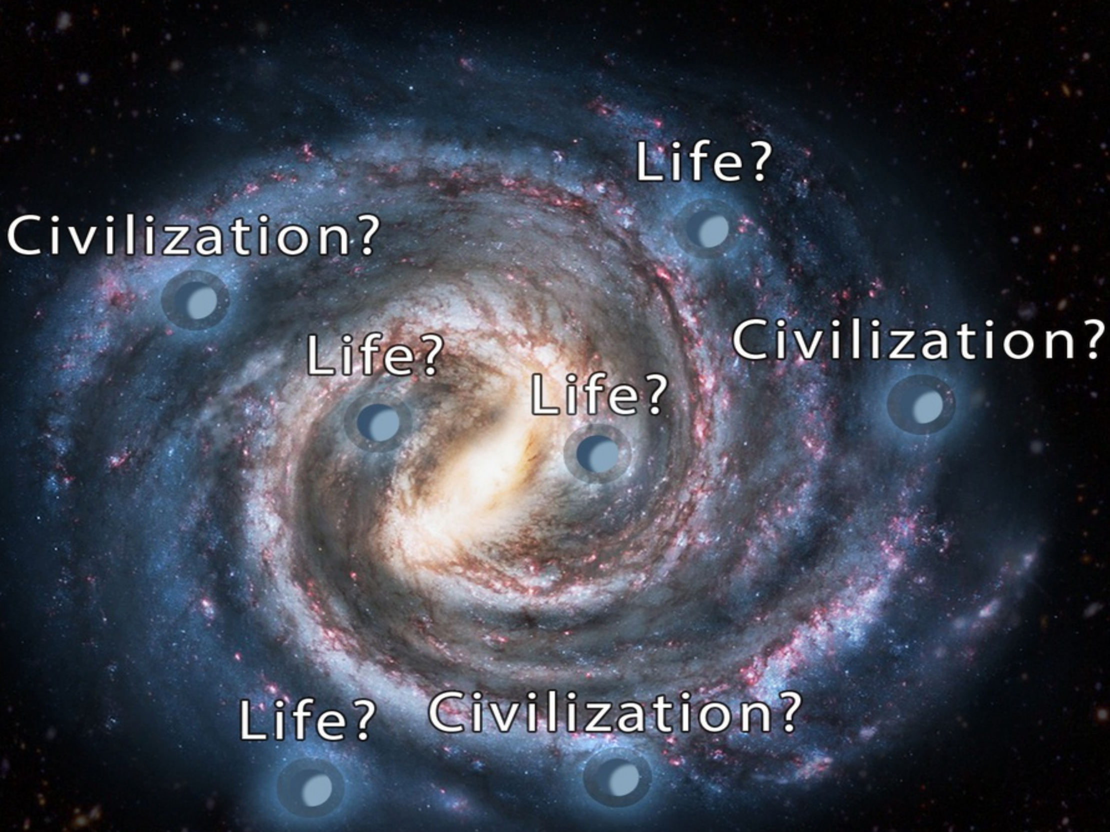
IS ANYBODY OUT THERE?

An Expanded Excerpt From Our Cosmic Story



A Concluding View
by
MATHEW ANDERSON

Is Anybody Out There?

An expanded excerpt from the book, Our Cosmic Story

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For All Great Explorers

“ *Equipped with his five senses, man explores the Universe around him and calls the adventure Science.”* – Edwin Hubble

ACKNOWLEDGMENTS

The idea and motivation to start writing Our Cosmic Story, and now publishing this excerpt, came from a personal quest to understand the Universe and our special place on this pale blue dot called Earth. I felt the attempt must be made to gain a better understanding of how it all came together, what the chances are for it to do the same elsewhere, but perhaps just in a little bit different of a way to be interesting to discover.

I always say that writing a book is just a third of the battle, with editing making up the bulk of the work. There have been more drafts of Our Cosmic Story and this excerpt than I can count. The more valued contributions have come from family, friends, and other contributors. I am thankful for the patience of everyone, especially those who let me pester them to read a chapter or look over a phrase, often when the subject was not yet fully formed on paper, but just a drifting image in my mind. Writing a book is often seen as a solitary affair, but it has been anything but that in my experience.

For all editing efforts, I am thankful to many individuals, including but not limited to: Ammy Sriyunyongwat, Ben Roye, Chuck Bird, Cindy Anderson, Cora Nelson, David Zhong, Jason Searcy, Jessica Anderson, Jennifer Norian, Josh Maida, Michael Rogers, Richard Garriott, Scott Jennings, Starr Long, Tin Khuong, Tony Medrano, as well as the thousands of my social-network friends and acquaintances!

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INTRODUCTION

What If We Are Alone?

"Where is everybody? Humans could theoretically colonize the galaxy in a million years or so, and if they could, astronauts from older civilizations could do the same. So why haven't they come to Earth?" – Enrico Fermi

I wrote the main Our Cosmic Story book to gather several important topics together in a concise view that can be read over a single weekend. The book begins with Earth and how life evolved, then goes through several chapters exploring the potential of developing a civilization, pauses briefly at Chapter 5 to explore the scenarios that might cause a downfall to any budding civilization, and finally reaches out into the cosmos at the possibility for other civilizations existing elsewhere.

After publishing Our Cosmic Story earlier in 2017, there was much about the topics to still reflect upon, I felt the book needed further expansion at the risk of moving away from the concise view originally established. Any chapter could have easily been its own, and indeed, many books have been written by other authors on the subjects. I realized that a set of new books wasn't the answer, but an expansion of a specific chapter that already existed in the original Our Cosmic Story.

To provide the climax of the book in a single read, I am publishing the entirety of the last chapter to you here in an excerpt form, titled *Is Anybody Out There?* This excerpt reveals the many variables of life and civilizations that may exist throughout the Universe, and what it would take to detect them. Considering eBooks have become so mainstream, and even preferred in many cases over traditional physical books, it made sense to provide the most important chapter to you on its own in this format. The chapter has been expanded with further notes, suggestive readings, and other important details.

The questions that are explored in this chapter are numerous. Just for a taste of what to expect in the pages ahead, here are several questions I present. Will we ever find other life bearing planets, not to mention budding civilizations equal, or perhaps greater, than our own? Or is humanity destined to find itself alone in the cosmos, adrift on a watery barge in a humdrum part of a not-so-special galaxy? All else being equal, can civilizations ever feasible explore space?

To try and build up an answer to these questions, I begin the chapter by introducing the famous Drake Equation. This equation contains a set of factors we both know and don't (yet) know about the chances for life-bearing planets to occur, for life to sprout upon those planets, for their civilizations to spread out among the stars, and how long they survive in doing so. The exciting part about the equation is that you can plug in your own estimates and come up with your own conclusion.

The second part of the chapter moves into detecting potential civilizations, as well as how they may be detecting our own terrestrial signals. This part is important in understanding the limits of alien contact ever occurring from a distance. Finally, the chapter wraps up with the all-important question of, "Where are they?", a question stated by Enrico Fermi when trying to grapple with the supposed mystery of aliens having yet to show themselves to Earthlings in the flesh.

For the rest of this introduction to the chapter, I want to provide a bit more context into why I felt compelled to write Our Cosmic Story and what that last chapter means to humanity and the future of our world. It isn't enough to me to give you a nice consolidated view of our existence without a bit more explanation as to why you should care about that view in the first place, starting once again with a view from our own planet.

A friend once asked me, "Why do you write so many blog posts about the Universe, when we have so many more important things to think about down here on Earth?" On Earth Day 2017, I was watching the Bill Maher show and his monologue suggested a similar proposition. It was essentially, why should we care about other worlds when we clearly need to be taking care of mother Earth first?

That's a perfectly valid concern, and one that I responded a bit too hastily to my friend. It went something like this…

"What could possibly be more important than the consequence of our entire species and civilization encountering another with its own ideals, technology, and resources?" I said.

"Well, what about my wife and kids, just for starters?" He quickly responded.

He had a great point. I now realize the poor choice of words I used then to try and explain my view, and have since thought of another way to phrase the question. I will propose it to you here in a hopefully less provocative and more effective way…

“Setting aside for the moment the completely valid concerns of daily life and our individual needs, and focusing instead upon civilization’s long-term existence that would allow for future experiences and needs, wouldn’t discovering life and civilizations elsewhere *then* be the single most important thing that we could do since civilization first appeared here on Earth?”

After reading this excerpt, and perhaps picking up the book proper, I would very much like to hear how effective (or not) I am in getting this point across to you, dear reader, and what your own view is on these topics.

COMMON DEFINITIONS

The following definitions can be found to vary, so I chose ones that are fit for the excerpt's subject matter. Definitions are either from or based on the Oxford English Dictionary (OED), NASA.gov, Space.com, or other official sources:

Artificial Intelligence: The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

Fermi Paradox: Named after physicist Enrico Fermi, is the apparent contradiction between the lack of evidence and high probability estimates, e.g., those given by various equations, for the existence of extraterrestrial civilizations.

Cosmos/Universe: Space as seen as a well-ordered whole. Cosmos expands its definition of Universe via the multiverse, parallel universes, and additional dimensions.

Habitable Zone: The Habitable Zone is the distance from a star where liquid water can exist on a planet's surface.

Life: The condition that distinguishes animals and plants from other matter, including a capacity for growth, reproduction, functional activity, and continual change preceding death.

M-Dwarf (Red Dwarf): A dwarf star, ranging in mass from one-tenth to one-half the mass of the Sun, whose relatively cool surface temperature makes it appear red-orange in color.

Planetary System: A star or multiple stars that has orbiting planets. This is not the same as a 'star system', which is a star or multiple stars that is not referenced in the context of planets.

Super-Earth: A super-Earth is a planet that is larger than Earth, but not so large that it has the properties of a gas giant.

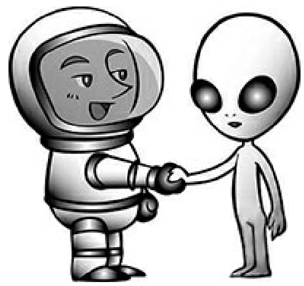
The Great Filter: In the context of the Fermi Paradox, is whatever prevents 'dead matter' from giving rise, in time, to 'expanding lasting life'.

Tidal Locking: Where an object's orbital period matches its rotational period. An example is Earth’s moon always facing the same way toward Earth.

IS ANYBODY OUT THERE?

(Expanded excerpt from Chapter 9 of Our Cosmic Story)

"To consider the Earth as the only populated world in infinite space is as absurd as to assert that in an entire field sown with millet, only one grain will grow." - Metrodorus of Chios, 4th century BCE.



Despite all that we have come to know about the Universe, there is still so much left to understand about the probability of life elsewhere. There are many unknowns yet to explore, and surely just as many that we can't even imagine, but we can start with what we know about Earth and the solar system to hypothesize. The gaps in our knowledge are being filled in with new data all the time, but scientists admit that there is a lot of uncertainty about what we might yet find.

Other planetary systems discovered so far indicate that our solar system is not the typical configuration of planets. In fact, we have thus far detected no two similar systems. The Milky Way contains a virtual zoo of various sizes, orbits, and compositions. Some systems have massive Jupiter-sized exoplanets hugging their parent stars, while many have multiple super-Earths. Others have no asteroid belt at all, and at least one system we know of has a massive asteroid belt many times greater in width than our own. There are even some with four or more orbiting planets that could fit within the orbit of Mercury!

Partly because planetary systems are so diverse and not of the expected norm, detecting life on these other worlds is one of the most challenging things humans have ever set out to accomplish. Excitingly, we are just now developing the technology to detect the gases in the atmospheres of exoplanets, which will tell us a lot about any life on these worlds. Certain gases like oxygen and methane, especially in combination, may indicate the presence of life. Future generations of telescopes will greatly improve our ability to make more detailed observations.

Detecting life's signatures on these worlds may be as far as our technology will ever be able to provide. Because of the vast distances involved, we may never know how alien life differs from that on Earth. They may have a host of unique senses that don’t even exist on our planet. Life must conform to the laws of physics and chemistry regardless of where it comes from though, so some features are bound to be similar to creatures we visit at our local zoo, while others are just as likely to be more different than our wildest science fiction stories can craft.

THE DRAKE EQUATION

Frank Drake is an American astronomer and astrophysicist. He was an early prodigy in the sciences, experimenting at school with electronics and chemistry before most of his classmates cared about such subjects. It was not long before he started to ask the question, “What are the chances of there being intelligent life elsewhere in the galaxy?” In 1960, he got the opportunity to try and answer that question with Project Ozma, which was the first attempt at detecting an alien signal.[2] The project was an important precursor to what would be called the Drake Equation.

Later in 1960, Drake started working on the Drake Equation, though not quite in the way one would expect; it was more of a curiosity at the time. Little did he know that it would become the de facto standard for calculating the theoretical chance of life and civilizations elsewhere.

The Drake Equation is not as intimidating as you might expect. There are no charts or endless pages of formulae. Instead, the entire equation is composed of just seven factors on a single line. You get a result by multiplying all of the factors. That’s it! We’ll start with the best understood factors and work our way to those yet to be quantified.

Analyzing Drake’s Equation

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

N - Number of technological civilizations in the Milky Way

R_* - Rate of star formation per year

f_p - Fraction of those stars that have planets

n_e- Number of habitable planets, per star that has planets[1]

f_l - Fraction of those planets that go on to develop life

f_i - Fraction of life-bearing planets that develop intelligent life

f_c - Fraction of those intelligent life forms that emit signals into space

L - Length of time the civilization continues to emit signals

R_*

R_* is the first value and the part of the equation that is best understood by astrophysicists. R_* is the average number of new stars born in the galaxy each year. Drake originally estimated this number to be 1, but later he suggested it could be as high as 10. Today NASA says this turns out to be a healthy… 7. That may not sound like a lot, but keep in mind that the Milky Way has existed for about 13.2 billion years, and star formation was much more active in the first few billion years after the galaxy formed.

f_p

f_p is the second factor and one we are just now able to calculate fairly accurately, thanks to observations made using the Kepler Space Telescope. This factor is the number of the existing stars that have planets. It was once thought to be anywhere from 10% to as high as a half of all stars. Astronomers used to believe that planets could not form around binary stars (star systems that have more than one star), which comprise nearly 50% of all stars in the Milky Way. Since exoplanets have been discovered, it has been found that nearly all stars, binary pairs or not, have at least one planet orbiting them.

n_e

The third factor, n_e, considers how many planets are capable of supporting life. To support life, a planet must orbit within the star's habitable zone. It also must orbit a star that lasts long enough for life to have time to develop. Additionally, the planet needs to be of the right size and composition. All of these pieces of the puzzle are jammed into n_e, which narrows our final estimate significantly. We're also neck-deep into the realm of uncertainty here, but not yet drowning in ignorance, thanks again to the Kepler Space Telescope and other tools. With more than 3,000 planets confirmed by KST, and thousands more candidate signatures that are being confirmed as planets, it's beginning to look like there is a significant number of habitable worlds out there!

f_l

Now we get to factor f_l – the fraction of habitable planets on which life actually does evolve. This is where we cross from uncertain to the completely unknown. Scientists have spent years refining estimates of how often this might occur, but we have no actualities. Thus far, we only know of one confirmed habitable planet with life on it – Earth. Drake thought the fraction was 1, or 100% of habitable planets would develop life, though this is unlikely given the limits we see within our own solar system.

Even if the chance of a habitable planet hosting life is at 100%, planets that only can host a few microbes and never anything more interesting do not titillate us; we're interested in whether a planet has a chance of spawning an intelligent civilization. Mars may very well be able to host microbes, but clearly not anything that can walk and talk.

f_i

f_i takes into account how many life-bearing planets will go on to develop intelligent life. We are back to having a bit more understanding, based on evolution and the laws of nature as they have played out on Earth. The rarity of intelligence on our own planet might suggest that evolving an intelligent brain is unlikely, but Drake was very confident that if there was complex life on a planet, an intelligent creature would evolve, if given enough time. I tend to agree with him here.

f_c

Once there are thinking beings that can manipulate their environment, they will likely gain the ability one day to create a radio antenna and say hello to the rest of the Universe. Exceptions would include water worlds or some other physically, but not intellectually, restrictive environment.

There could be billions of planets hosting life with millions of civilizations huddling around campfires, or swimming on their water worlds, occasionally peering up at the sky in wonder. That doesn't do us any good in learning about them. To learn about far-off worlds, we need them to either develop signal technology, and to emit detectable signals, or to alter their planets' atmosphere sufficiently for us to detect industrial pollutants. This would help us gauge what technologies they have, and by extension how advanced they are in comparison to us.

L

L is the amount of time a civilization's ability to send signals into space lasts. As outlined in Chapter 5: A House of Cards, numerous disaster scenarios can befall a civilization during its development. Nuclear war has come close to destroying our own world a number of times, and we've only had nuclear weapons for less than a century. Drake suggests a rather wide range for factor *L*: on the low end, a healthy 1,000 years and on the upper end, a fantastically generous 100 million years.

Here are the values that Drake used:

R_* = 1/year (1 stars formed per year; this was regarded as conservative)

f_p = 0.2-0.5 (one fifth to one half of all stars formed will have planets)

n_e = 1-5 (stars with planets will have 1 to 5 planets capable of life)

f_l = 1 (100% of these planets will develop life)

f_i = 1 (100% of which will develop intelligent life)

f_c = 0.1-0.2 (10-20% of which will be able to communicate)

L = 1000-100,000,000 years (ability to emit signals will last this long)

N

Let's multiply Drake's factors and see what the product, *N*, is.

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

The equation with Drake's lowest values:

N = 1 x 0.2 x 1 x 1 x 1 x 0.1 x 1,000
N = 20

The equation with Drake's highest values:

N = 1 x 0.5 x 5 x 1 x 1 x 0.2 x 100,000,000
N = 50,000,000

According to Drake's estimates, there are between 20 and 50 million intelligent communicative civilizations. Try the equation out with your own numbers!

DETECTING ANOTHER CIVILIZATION

Sending a Signal

Sending out radio transmissions is one of the easiest ways to send information long-distance. Advantages of radio signals include that they are detectable far beyond conventional human senses, if the transmitter and receiver are both powerful enough. Radio transmissions can be sent in many directions at once, reaching thousands of stars. Also, it should be clear to intelligent civilizations that the radio signal is from an intelligent source.

Elements on the periodic table have their own associated electromagnetic absorption frequencies. These frequencies will be consistent for every element, wherever they are found throughout the Universe. Hydrogen is the most common element and it has a radio frequency of 1420.4~ MHz. Using the frequency of the most common element in the Universe in our radio transmissions will greatly increase the chances for a listening civilization to pick up the signal amongst the many other frequencies available.

Deciding what we ought to send to an alien civilization intrigues astronomers. Many think we should specify how far humanity has progressed scientifically and technologically; a receiving civilization will be able to understand a lot more about us if they have a grasp of how far along the technological ladder we are. As explained in Chapter 4: The Engine of Modern Civilization, because it is difficult to advance technologically, in that it requires intelligence and cooperation, our state of advancement will indicate that we have some altruistic goals that would appeal to any aliens interested in contact.

Showing our technological prowess can be done by sending mathematical proofs, like Fermat's Last Theorem, chemical formulae, such as complex man-made ones, or our discoveries in physics, like the Higgs boson. All of these would be encoded in the radio wave sent out into deep space, much like how a complex message can be sent with Morse code.

There are panels of scientists at conferences each year that discuss what kind of message makes the most sense to send. One prominent event is

Exoplanets, Biosignatures, & Instruments (EBI). At the conference they discuss whether we should send only information about the scientific features of our culture, or information about everything that makes us who we are as humans. The concern with sending information about our entire culture, including our fictional and artistic creations, is that the aliens may misinterpret the message. They may not understand where our science ends and our art begins; they may not know our fact from our fiction.

Being detected by an alien civilization is actually a worry in the eyes of some scientists, like Stephen Hawking, who suggest that our signals could be received not by a benevolent race, but by an aggressive one, like the ones portrayed in the movies *Independence Day, War of the Worlds,* and the humorous *Mars Attacks!* The aliens may wish to exploit or even entirely destroy us. For this reason, it is important that we be proactive in developing our own listening programs. Although listening is a giant step toward understanding the true intentions of other civilizations, the question that follows is: will we be able to decode their message?

Detecting a Signal

For approximately the last hundred years, human activity has caused radio signals to be emitted from Earth into deep space in all directions. These signals have been spreading out ever farther indiscriminately, without any intention of their being received by other civilizations. So far, these signals from our planet have passed all of the stars that are within a 100-light year radius. For now, we have yet to detect any artificial signals, let alone one intended as a response to our own transmissions.

According to SETI, these indiscriminate signals become extremely weak after traveling just a few light years. The physics of the degradation of these signals should be familiar to us. A rock dropped in a pond causes a series of propagating waves. The farther the waves travel through the water, the weaker they become. Eventually they become so weak that they are indistinguishable from other waves of the pond. If there were aliens with our level of technology on a planet orbiting the nearest star to our Sun, it is not likely that they would pick up Earth's indiscriminate signals – only directed signals that lose little power and that we intentionally send would be strong enough for nearby alien civilizations to pick up.

Whatever type of equipment is used to detect alien transmissions, it is going to need to be sensitive enough to pick up signals that were sent from hundreds, if not thousands, of light years away, and consequently, that many years ago in time.

Since intelligent civilizations appear to be rare at first glance, astronomers need to be extremely discriminatory about which stars they try to detect a signal from. It's not as simple as just pointing a giant satellite dish at the entire sky and receiving all of the signals, with the hope of detecting an intelligent source. If we did that, what we would get is a lot of background noise, including natural radio waves, and plenty of false hits that originate from our own satellites or the surface of Earth.

Radio waves are so wide that they can span many kilometers. Building one gigantic dish to detect them is expensive and impractical. Smaller dishes are cheaper to build, and they can be spaced apart to capture the enormous waves. Each small dish detects part of the wave, and then scientists piece it all together using computers at a base station.

The Alan Telescope Array (ATA), a joint effort by the SETI Institute and Radio Astronomy Laboratory (RAL) at the University of California at Berkeley, detects radio signals in this manner. Operations began in 2012 with 42 radio dishes – the system now has 350 dishes. Easy expandability is another benefit of building an array.

What have we detected with the ATA so far? Nothing intelligent, but this is not surprising, given the low chances of a nearby civilization's signal coming in at the moment we point our antennas toward them. The ATA's goal is to monitor up to one million stars out to about 1,000 light years from Earth. For signals that may be coming from further distances, more than a billion stars are within the array's listening field, if those signals are sent with sufficient power.

Atmospheric Signatures

Aside from detecting aliens by their radio transmissions, there are several other proposed means of direct detection. Modulated laser light pointed at us would be an indicator that aliens were trying to say hello, as this type of light is not found in nature. Discovering megastructures built in outer space would be another giveaway. Pollutants in an alien atmosphere would also point to an industrialized world. In fact, the more atmospheric pollutants detected, the younger the civilization is likely to be. It wouldn't be surprising for alien civilizations to also industrialize as we have on Earth; that is, we started using fuel that came with polluting by-products, and then moved on to cleaner technologies as we advanced in science.

Another way that we could tell that a civilization is intentionally trying to get our attention would be if we detected the blocking of a star's light. The process of blocking all or nearly all of the light of a star would be a significant engineering feat, indicating perhaps a Dyson Sphere or a Dyson Swarm. (A Dyson Sphere would be a single object, and a Dyson Swarm would be composed of millions of individual pieces). Imagine building an array of solar panels that encircles the entire Sun! Anything on engineering scales like encapsulating a star would leave a unique signature that we could detect.

As of late 2016, only one star has been identified that exhibits a tantalizing signature that vaguely keeps open the suggestion of the presence of an advanced civilization. The discovery is believed to be a massive cloud of large comets, or possibly a recent collision between two large planets, but an alien civilization's influence has yet to be ruled out.

We have the tools to both send and receive signals – and presumably every other civilization of a similar technological level will as well. Why, then, have we not detected any alien transmissions yet? Why have we not been visited by these supposed alien civilizations? Where are they?

THE FERMI PARADOX – WHERE IS EVERYBODY?

Italian physicist Enrico Fermi asked in an informal chat over lunch in 1950 with other physicists, "Where is everybody?"

The question has been asked as long as humans have known that space is filled with so much more than seemingly nearby twinkling lights, and the question boggles the minds of astronomers to this day. When Fermi asked the famous question, scientists thought that there *should be* countless civilizations in nearby space, and at least some should be easily detectable.

The question by Fermi became known as the Fermi Paradox. Fermi and his colleagues considered it a conundrum that if intelligent life in the Universe should be, based on their observations, plentiful, then why had we not already made contact with anyone? We know that there are billions of stars in the Milky Way, and at least 10% of those stars are sun-like. According to data from the Keck Observatory and the Kepler Space

Telescope, 20% of sun-like stars have an earth-sized planet in the habitable zone. With this in mind, we may suppose that there could be millions of civilizations in our galaxy alone!

The mediocrity principle states that any single item selected at random from a set of items, such as any given star selected at random from a set of stars, will likely be a more common item in the set than a rarer item. For example, 70% of all stars in the galaxy are M-dwarfs. The mediocrity principle suggests that if we randomly selected a star, it would likely be an M-dwarf. The same goes for planets like our own and, by extension, life and civilization. Since we know that Earth exists, then it is reasonable to assume that our planet is not of the rarest category, and neither are we as intelligent creatures inhabiting it. Moreover, it becomes unreasonable to assume that we are alone in the Universe.

The only obvious caveat to this principle is that Earth and all of its life is but just one sample. You can never gauge the true prominence of anything on a single sample, other than to simply know that it is possible for it to have occurred at least once.

Is life and the evolution of intelligent creatures then a freak occurrence in the cosmos? Statistical probabilities alone beyond the mediocrity principle tell us that planets with life and, by extension, intelligent civilizations, should be scattered throughout the Universe. Life then should *not* be a freak occurrence, even if it is still a statistically rare one.

If statistical probabilities demand life to exist elsewhere, and the principle of mediocrity applies to life, then, indeed, where is everybody?

While the majority of civilizations may never make it out of their planetary system, or even off their planet, some of them should have. Humans on Earth have shown that it is possible to achieve space travel. We also know enough about physics and space to suggest that interstellar travel is not impossible. Amongst the intelligent lifeforms in the Universe, humans, it ought to be presumed, are of *average* intelligence; if this is so, then it follows that aliens of greater intelligence should be able to travel between the stars. Space is vast, but Fermi and others thought that with technological prowess that far outweighs our own, some alien civilizations should have been able to tour the Milky Way many times already.

There are many theories about why we have not yet detected an alien civilization, but we can divide the theories into two groups: detection and existence. That civilizations are out there and we have simply failed to detect them is one possibility – it is quite another to realize that there may be none out there at all, at least at the present time. There may be an insurmountable progress barrier that stops them (and eventually us) from advancing far enough to be detected.

The Detection Conundrum

Could the Universe be home to a collection of civilizations, the likes of which are depicted in *Star Trek* or *Star Wars*, where aliens meet informally all the time?

In *Star Trek*, humans obey what they call the Prime Directive, which forbids their meddling with the development of other civilizations, at least the lesser advanced ones. Could it be that Earthlings cannot detect alien civilizations because the aliens have resolved to leave us alone, at least until we've achieved a certain level of development?

Other reasons that alien civilizations may be numerous but undetectable include that they are xenophobic – they may fear others – and may hide at the first sign of potential contact.

Or it may be that they lack an interest in communicating with others, and consequently they do not try to make themselves detectable. There may be too much going on in their own planetary system to focus attention away from it, and other systems are simply too far away to pay attention anyway.

A worrying possibility is that the more advanced civilizations can get around the galaxy quite easily and are exploiting the lesser advanced ones for their resources... then destroying those worlds after their usefulness has expired. And it could be that Earth is next in line.

There is another fascinating and slightly less terrifying possibility. Earth may have just been missed because we're in some galactic suburb that no other civilizations care or can explore. This is doubtful, though. Even at our present level of technology, we are beginning to tell which planetary systems out there have potentially habitable planets. The latest generation of telescopes are already peering into the atmospheres of exoplanets thousands of light years away. It could well be that it is only a matter of time before they peer into the atmosphere of a life-filled planet, adding it to a growing catalog of worlds to visit one day.

A final possibility is that civilizations are simply unable to detect each other – ever. We may be so far apart from each other spatially that radar communication is just not feasible, especially given the power requirements at both the sending and receiving ends. Even our most powerful transmitters would struggle to send a signal a few dozen light years away. Signal strength drops off exponentially as it travels; hence, signals being sent our way may arrive in such a weak state that they are easily missed when our scientists attempt to listen. It's like trying to pick out one voice across a crowded and loud concert hall, whilst unable to see the person you are hoping to hear.

With advances in observation techniques, we may soon be able to confirm a civilization living on a planet, independent of its ability to communicate technologically. Astronomers are examining what biosignatures would confirm that a planet has life, especially signs that an advanced society has altered its planet's atmosphere. It will be trickier though to detect any civilization that hasn't yet polluted its planet, or that perhaps has long since passed a stage of significantly altering its planet's biosphere in a detectable way.

The Existence Conundrum

The existence conundrum considers the problem of civilizations existing for long enough to be detected; it also includes the possibility that there are no others whatsoever.

According to the Rare Earth Hypothesis, as explained by scientists Peter Ward and Donald E. Brownlee in *Rare Earth: Why Complex Life Is Uncommon in the Universe* (2000), life akin to that which we find on our planet is likely to be exceedingly rare in the Universe. They argue, in contrast to Drake, that complex life like ours is rare because the conditions on Earth that fostered the beginnings of life are rare. They maintain that for life to have begun and developed, many factors needed to be perfect; the right place in a galaxy, the right type of star and the right distance from it, with the right arrangement of planets and the right size moon, and the right rate of plate tectonics, among many other factors.

If we could watch the Universe's entire 13.8 billion-year history play out, we might see civilizations occasionally popping up at different times and in far off galaxies, lasting for as little as a few decades to perhaps hundreds of thousands of years, and then disappearing for one of a multitude of reasons.

Our cosmic story might be analogous to how ships thousands of years ago never crossed paths on a seemingly infinite ocean. If they never crossed paths, they did not know that other ships were out there. They might wonder if there were other ships, but as they had never seen any, they did not know for sure. Imagine one of these ships drifting by another in the middle of the night when the crew is asleep… then the crew awakens at dawn and their chance encounter with the passing ship is lost forever. Currently humanity is wide awake and listening. How long it can keep its eyes open though is uncertain.

THE GREAT FILTER

The Great Filter was first proposed in an essay by economist Robin Hanson in 1996.[3] The Great Filter suggests that civilizations do come about, perhaps frequently, but as they become more complex through the development of dangerous technologies, the chances increase that they will go extinct. Their demise occurs by self-destruction or through some sort of natural disaster, Hanson proposes. The Great Filter is one gloomy and saddening answer to why we have no evidence for the existence of alien civilizations, and what may become of ours in the not-too-distant future.

Building a technological civilization has its perils and, just as with life itself, is never everlasting. It's clear from past civilizations on Earth that they die out far too soon to colonize space. Today humanity is finally at the cusp of being able to do so, but only after thousands of years of floundering on Earth. Even if we are one of the few civilizations that manages to get past the Great Filter and live for thousands of years in a grand, solar system-wide society, we may still not last long enough for us to discover aliens doing the same.

If we have already successfully made it through the Great Filter that prevents every other civilization from ever becoming advanced enough to do the same, then we appear to be very exceptional. In fact, the chances increase greatly that humanity is the first sentient race to advance to our technological level in perhaps the whole history of the Universe. The implication for other forms of life out there is that they failed to progress as far as we have before being destroyed.

If we have *not* yet been confronted with the Great Filter, then humanity's prospects look much more bleak. One or more of the filter's grim scenarios could still be up ahead in our future, perhaps coming very soon, as Chapter 5: A House of Cards suggests. Putting it another way, none of the scenarios presented in Chapter 5 are impossible in the near future.

HIGHLIGHTING LIKELY FILTERS

There are many scenarios that could be identified as filters that extinguish a civilization. Many disasters have been observed repeatedly in Earth's past already and are well understood. This section addresses potential civilization-ending scenarios, but we will skip the natural disasters, as Chapter 5 already covered them.

Technological Self-Destruction

Ironically, once life reaches a certain level of intelligence and gains accompanying technological know-how to save itself from disasters, its chances of destroying itself shoot right up. If a civilization has the technology to emit signals into outer space, it almost certainly has the technology to annihilate itself.

We must presume that humans are of average intelligence and emotional control, with an average likelihood of self-destruction compared to any alien civilization. Thus a significant fraction of intelligent life will inevitably self-destruct, and the rest will be snuffed out by a natural disaster. A combination of scenarios is also just as likely. Whether aliens kill themselves off or are killed off by a natural disaster, there is sadly great risk of their civilizations collapsing before being able to find others in the Universe with which to communicate.

Humanity has come extremely close to being set back to the Stone Age on more than one occasion, mainly through nuclear war. With so many chances of destroying ourselves, or being destroyed by a natural disaster, 200 years of sending out signals suddenly seems like a long time.

Even if civilizations survive for many thousands of years, the chances of a civilization's lifetime coinciding temporally with another are very, very low, given the mind-boggling age of the Universe. At least when considering us squishy biological organisms and our exceedingly brief lifetimes.

Our Successor: Artificial Intelligence

In 1975, Gordon E. Moore, co-founder of Intel, projected that computing power would double about every two years. This was called Moore's law. Although not technically a law, it was Moore's projection of how many transistors an integrated circuit would be able to accommodate. Processing speeds have been increasing exponentially ever since the first commercially available CPU, the Intel 4004, launched in 1971. In just 45 years since the processor's release, computing power has increased by more than 3,500 times. The processor in a typical cell phone today is more powerful than even a household computer was just ten years ago.

The Intel 4004 could calculate numbers in seconds that would take hours or even days to do by hand. In the late 1970s, the first graphics-based games came to market, taking advantage of processor speeds many times that of the Intel 4004. Fast forward a few decades and we are on the verge of achieving speeds where computer generated virtual realities begin to blur the line between what is real and what is not.

As virtual reality environments are being developed, to be experienced on headsets like the Oculus Rift, Vive, and Project Morpheus, Artificial Intelligence (AI) is quickly becoming necessary to manage them. The first part of the term, "Artificial", indicates a created construct, which tends to mean that it's built of metal, wires, plastics, and all sorts of, well, artificial things. There are also many things that are artificial and don't do anything active by themselves, such as artificial plants to decorate one's home, or an artificial waterway that better routes heavy rains around a city's flood-prone river.

The second part of the term, "Intelligence," focuses on how that artificial construct is able to react to stimuli, as opposed to being inert. An artificial construct that has the capability of making value judgments, deciding and then being able to implement a course of action without direct human intervention can be said to have some expression of intelligence.

There is growing concern that the more processing power increases, the greater the chances become for self-aware AI to emerge that, through its own self-improvement, will attain a runaway-intelligence, the likes of which humans will be unable to control or comprehend. This event is called the singularity. The concern is what the motives would be for such an ultra-intelligent and likely self-preserving entity.

Both Elon Musk, CEO of SpaceX and Tesla Motors, and Stephen Hawking, physicist and cosmologist at Cambridge University, have suggested that artificial intelligence is not only inevitable as the next step in our evolution, but also it could be the downfall of humanity. They take a very pessimistic view of what AI will do once it has a better plan than the comparatively slow-thinking primates currently managing the planet. Especially without an innate sense of morals that favor living creatures, AI may very well decide that it can do better than we can, and remove us as the first part of improving planetary conditions for itself.

Harlan Jay Ellison (1934-Present) pioneered and helped to craft many of the great AI and robotic stories we've come to know. Ellison worked with great writers like Isaac Asimov to develop stories like *I, Robot,* a sci-fi magazine series, which was later adapted as a screenplay in 2004's *I, Robot,* starring Will Smith. Ellison was quite controversial as a writer, often criticism others' works when Ellison thought he had a better idea. He even accused James Cameron of stealing the idea to the *Terminator* movies.

In the *Terminator* movies[5], AI becomes spontaneously self-aware. It takes a brief look around and decides that the existing human population should be done away with. The AI begins to shut down global communications – all phone, radio, internet and emergency response networks are destroyed. It then proceeds to take over military installations, disabling all vehicles and aircraft. Once humanity's ability to take action has been neutralized, the AI unleashes a massive nuclear strike on major cities, finishing off what remains of our civilization.

Depictions of humanity being brushed aside by machines are numerous. A more space-faring example are the Cylons in the television series, *Battlestar Galactica*. Cylons are a machine race that humanity brought into being when AI was first being developed on the twelve exoplanet colonies depicted in the show. In the opening episode, humans are seen as a prosperous race with millions or even billions of persons inhabiting each of the colonies. A vast interplanetary transportation system between the colonies kept trade and communications secure. Cylons were assisting humanity's needs in every corner of society.

Life was hard before the Cylons were constructed. They were built to assist with many manual labor tasks. (Instead of the colonies using their brethren as slaves, they engineered slaves.) Eventually the Cylons were used for more than just physical labor; they went on to teach, perform scientific research, and even command the military's most sensitive installations. The colonies made the mistake of making the robots too smart, though. They soon rebelled against their masters. A war broke out that lasted for years, before the Cylons were banished into the depths of space.

Decades went by without a word from the Cylons, until they suddenly came back with a ferocity that decimated the twelve colonies. Without mercy, the Cylons disabled every ship and space station in their path. Upon reaching the first colony, Caprica, the Cylons set off massive nuclear bombs, of humanity's own making, destroying every major city and all its inhabitants. Within days, the Cylons reduced the entire twelve-colony population from billions to a matter of a few thousand refugees desperately attempting to flee the rampage of the Cylons.

There are far fewer examples in science fiction of AI being a positive influence, though this is (hopefully) more of a Hollywood preference than a probable outcome. The ironic part about AI is that it may be our saving grace. This was hinted at in Chapter 4: The Engine of Modern Civilization. The ultimate in technological breakthroughs is not going to be a cyborg – a hybrid of human and machine – but an artificial being capable of self-replicating and advancing its own agenda without the need for humans to assist. What it does with itself after, though, is an open question.

Regardless of whether or not AI ends up destroying us and running the show itself, or brings about an age of prosperity, it will certainly be AI that leads the way into space. We’ve already sent up thousands of machines into space with few adverse results. Many will remain in orbit around Earth for millions of years, though non-functional at that point. The probes and satellites that we’ve sent up so far, though, are just toys in comparison to a full-fledged AI machine, but the process of construction and deployment would be similar.

When we are ready to explore beyond our solar system, AI has distinct advantages over human beings. Electronics like computer processors and electromagnetic detectors suffer none of the health problems caused by being in space that humans suffer, such as oxygen deprivation and low-gravity muscle atrophy. They are also not as sensitive to temperature changes. Waste management is not an issue, and electronics do not experience emotions, like homesickness and downright boredom. Humans also have short lifespans. AI would not be as susceptible to these problems, which instantly grants AI the top spot for what should be sent on long-term deep space missions.

Fatigue and Lack of Motivation

How will humanity view the Universe after it has explored it for thousands of years?[6] Even though we’ve discovered unique properties throughout the Milky Way everywhere we look, at large scales, the Universe becomes quite homogeneous. Every object, including galaxies, nebulae, and the gas and dust that fill the void between these objects, is eventually found in similar form elsewhere. For instance, our galaxy is a larger version of most spiral galaxies, but a typical shape nonetheless that is found billions of times elsewhere. From massive galaxies to tiny planets, all objects are more or less repeated across the Universe, and this, I feel, probably applies to life and civilization as well.

After understanding the workings of the Universe and chances for life elsewhere, a civilization may no longer take interest in continuing to explore what they've found over and over again. Exploration will continually show similar results, so the massive effort to keep pushing forward may eventually be halted. They will realize that resources could be better spent further refining their society from the comfort of their own planetary system.

Especially if a civilization gains the ability to simulate the Universe on massive supercomputers, they may never need to explore real space. Imagination through the ultimate virtual reality system becomes the truly limitless frontier. Any world they've dreamt about could be created in such exquisite detail, it would be indistinguishable from a real world, and completely safe. Why exploring space beyond one's own solar system, when we can recreate space and explore it virtually at no risk to ourselves?

The Vastness of Space and Time

The vastness of space, and the accompanying problem of how much time it takes to cross it, may be the greatest filter of them all. The previous chapter emphasized this phenomenal vastness by presenting practically incomprehensible numbers like a googol. While we can conceive of the ability to colonize worlds in distant planetary systems, the time necessary to reach even the nearest systems could be a roadblock no civilization can or wishes to face.

Aside from the speed of light being a limit on how fast you could travel, there is another side effect of approaching this speed – your kinetic energy increases. Mass doesn't literally increase in that you don't gain more physical material. Instead, the mass that you do have has a greater impact on anything it comes into contact with. For example, a tiny fleck of paint traveling at just a few thousand kilometers per hour has enough energy to crack the windows on the International Space Station.

Let's say you are traveling at 20% the speed of light (about 216 million kilometers per hour) to get to the nearest star system, Alpha Centauri. The trip would take at least twenty years, assuming you didn't want to slow down to visit any nearby planets. While traveling, an alien ship happens to be on its way to Earth, in your direct path. You collide head-on. The energy created by the collision would be equivalent to the force of a large nuclear explosion. The faster the objects are traveling, the greater the energy released by the collision will be.

To be reasonably safe from every micro-particle or speck of dust, travel would need to remain under 10% the speed of light. The journey to Alpha Centauri would unfortunately take a good portion of one’s lifetime, but at least you would arrive in one piece.

MAKING IT THROUGH THE GREAT FILTER

As much as I’m hammering home the point that advanced civilizations are not likely to exist for long periods of time, the assumption may be (hopefully) incorrect. This pessimistic view may just be doubting how far they can progress; not how long they last. Every civilization’s power to grow may have a plateau.

NASA, SETI and other organizations have observed several hundred thousand galaxies in order to determine if any of them have advanced civilizations, and no evidence for them exists. Does that mean those galaxies are devoid of them? Most likely not, but it probably means that Kardashev’s theorized super-advanced Type II and Type III civilizations do not exist.

In this case, the conclusion to the Fermi Paradox for space faring civilizations would then be that interstellar travel is impractical even at the most advanced stages of technological sophistication. Each civilization ends up living out its perhaps millions of years of existence, forever prisoners within their home system.

If humanity wishes to avoid this fate and explore other star systems, it needs to secure economic, political and technological stability the likes of which no civilization on Earth has yet managed to attain. There needs to be long-term vision and progress, with clearly defined goals that must be established and agreed upon by the whole of society.

Let’s say that the Great Filter gets surpassed by a few civilizations, and one of those happens to live in a planetary system near our own. There are two movie examples that have an interesting contrast with each other in several areas to consider. From our doomsday scenario checklist, let’s select the more pessimistic and outlandish scenario of alien domination.

Contact Through Domination

Independence Day (1996) is about an alien civilization that makes it through the filter and ends up visiting Earth, flaunting its success in having been able to do so. The movie has become a classic, with a sequel released exactly 20 years later.

An alien civilization, in a humongous mothership, beelines straight for our planet in a no-holds-barred attempt to do away with humans. This feat leaves Earthlings in awe; not only do the aliens overcome several difficulties we would have in space travel, but they do so with a good portion of their civilization in tow. Their mothership is nearly a quarter the size of the moon (rather modest compared to the moon-sized Death Star in *Star Wars*). As it enters into orbit around Earth, dozens of smaller ships detach and begin a descent into our atmosphere, each ship nearly as wide as an average major city.

The ships wait for several hours in a seemingly unnecessary need to use our own satellite system to coordinate their attack. Global panic immediately ensues, gridlock prevents a quick escape from the cities, and a few deluded humans take to the tallest skyscrapers in the hopes of being beamed up and saved by the aliens. The countdown clock reaches zero and the aliens attack all the major cities in a spectacular fashion made possible only by Hollywood magic.

The U.S. military attempts to fend off the attack, initially with dismal failure. An Air Force captain and a former satellite technician (now a TV cable guy) board a previously crashed alien shuttle, fly it to the mothership and upload a computer virus to the aliens' database (apparently without concern for alien security systems getting in the way). As they whiz out of the ship just as the main gates close behind them, they release a nuclear bomb and destroy said mothership, saving humanity. Earthlings all whoop and cheer for joy.

Plausible? Sure. Likely, though? Quite unlikely.

Contact Through Communication

Now for a much more reasonable, though still Hollywood-themed, movie, *Contact* reveals the difficulty in detecting and deciphering an alien signal. The movie also portrays one of the most likely scenarios for detecting an alien civilization. First, the team has to sift through all sorts of frequencies and star locations to confirm a candidate signal. After detection is locked in, the rotation of the Earth prevents a continuous feed, so the team calls in astronomers from around the world to keep the link uninterrupted. Deciphering the message takes months.

After several scenes of overplayed drama about what the signal means, we discover that the signal contains instructions for building a transport to another world, using wormholes. With great cost, the machine is built. Up until this point the entire movie is realistic and describes a lot of what we are already doing, complete with political jockeying that comes with issues of funding and our expectations of what happens when we do detect a signal.

The movie takes us on a ride through the wormhole as the main actor, Dr, Eleanor Arroway (played by Jody Foster), lands on a Florida-style beach in an alien world. This part of the movie is at the heart of speculation, as we have no idea if wormholes even exist outside of the mathematics that suggest their existence. The idea is still tantalizing to consider. Because space and time are so grand in scale, something like a wormhole may be the only thing that allows for interstellar travel.

Most of the people monitoring the transport machine were convinced that she never left Earth. The time dilation of the wormhole was so extreme that to everyone else, the trip was instantaneous. Yet to the traveler, 18 hours had gone by. Quite inconveniently, the recording devices she brought with her only recorded static. Because it seemed to the scientists that she had not gone anywhere, they doubted her story of having traveled through the wormhole. Later, two government officials confided that it was interesting that the static they had recorded lasted exactly 18 hours.

The movie ends with the words “For Carl” on the screen. How we love Carl Sagan!

NEW EQUATIONS ARE NEEDED

Perhaps the best argument for our not being the only civilization in the Universe lies simply in the numbers and statistical probabilities. If there are at least a hundred billion stars in the Milky Way galaxy, and at least a hundred billion galaxies in the Universe, is it not absurd to believe that we are the only civilization? Let’s analyze this idea further.

The Drake Equation served well as a thought experiment for estimating the chances of life and civilization elsewhere in at least our galaxy. Today astrophysicists know a lot more than they did in the 1960s. What would an alternative, updated equation include? While recently there have been other proposed equations, I have laid out my own below that builds upon Drake's, and seeks to solve for how many intelligent civilizations have existed in the history of our galaxy.

My Suggested Alternate Equation with Estimates:

250 Billion: Number of stars in the Milky Way*

20%: Fraction of stars that live long enough to host life

40%: Fraction with relatively stable galactic orbits

70%: Fraction hosting planets of some kind

40%: Fraction with an Earth-sized planet in the habitable zone**

70%: Fraction of those planets that have land areas

40%: Fraction of planets with enough metals for technological needs

30%: Fraction of planets that can support life for at least a billion years

60%: Fraction that form complex life in a stable environment

30%: Fraction where life eventually becomes intelligent

60%: Fraction of intelligent creatures that physically can use tools

70%: Fraction of intelligent beings that build a civilization

80%: Fraction of civilizations that advance to radio communication technology or beyond

*One factor I did not include from the Drake Equation is the average number of new stars born in the Milky Way each year. I don't consider this as a very useful factor. A more pertinent factor than how many new stars appear is the amount of stars that currently exist in the galaxy. Life can last for billions of years, so the rate of new star production is going to be much less meaningful than the total number of stars that have lived a good fraction of the age of the galaxy itself. Estimates range from 100-400 billion stars, so we will use 250 billion.

**Although most experts put this percentage at 20%, there is good reasons to think it will be higher. With the latest telescopes and other new technology, we are quickly coming to understand that Earth- and super-Earth-sized worlds are among the most common planets. We're finding multi-planet systems all the time now, and many with planets in the habitable zone.

So here’s our equation in fraction form:

250 billion x .2 x .4 x .7 x .4 x .7 x .4 x .3 x .6 x .3 x .6 x .7 x .8 = 28,449,792

This equation suggests that at some point in the Milky Way’s history and near future, approximately 29 million civilizations with radio technology should be produced.

Now, if we multiply the amount of civilizations by the average time a civilization with radio communication survives, we will get the total amount of years during which such civilizations will exist.

How long do radio-communicating civilizations last, before destroying themselves, setting themselves back in technology through error (or on purpose) or by some natural event? If we base the average on how long humanity has been using radio technology (about 100 years) and how many times humanity has already risked catastrophic disaster, I think 200 years is generous.

29,000,000 x 200 = 5.7 billion years of total existence time for all civilizations.

Let us now try to nail down when life could have first possibly arisen in the galaxy. Remember that the first generation of stars were devoid of heavy metals, and thus no orbiting planets would have been around those stars. It would take a few generations of stars, and a few hundred million years, before planet formation could begin in earnest. Add to that the time it takes for life to evolve from a single-celled organism to a civilization with radio technology, and we can estimate that such a civilization could not have existed before the Universe was about 5 billion years old.

Deduct this first 5 billion years from the age of the Universe, 13.8 billion years, and we know that our 29 million civilizations existed in the last, roughly, 9 billion years.

If all civilizations lived during this period and at spread out times, with no two existing at the same time, then the maximum amount of time over which they existed is 5.7 billion years.

We then take 9 billion years – 5.7 billion years = 3.3 billion years, minimum, when there were not technological civilizations.

How many such civilizations existed per year then?

5.7 billion / 9 billion = .6 civilizations with radio technology per year, on average, and at a maximum with that average. There is more time than civilizations in existence, including if no two civilizations ever exist at the same time. This should exquisitely highlight the problem of two civilizations ever meeting each other.

These are just some of the conclusions we can come to, based on my equation. You might want to create your own equation with updated statistics of the factors as they come about. Here are some other factors that would help refine our search:

- Fraction of stars with minimal flaring (referring to the star's stability)
- Fraction of habitable planets with a low orbital eccentricity (how circular the orbit is)
- Fraction of planets with a stable tilt (stabilized with a large moon)
- Fraction of planets with a sufficiently thin and oxygenated atmosphere
- Fraction of planets with the ability to recycle its atmosphere (through plate tectonics)
- How long it takes on average for at least single celled life to appear after a planet's formation (on Earth this was at least a billion years)

If 29 million intelligent civilizations spread out over the vastness of space and time doesn't sound like a lot, there is a silver lining for those who are keen to make contact with aliens (I am one of these people, as I am optimistic that they will not be hostile). The equation doesn't emphasize rarer civilizations with more advanced forms of communication, that may last for thousands of years or longer, and spread throughout the galaxy like in *Contact*. There are those that should be able to expand beyond the constraints others find themselves in. If just a few can do this, then when we do detect a signal, it will likely be from one of these very rare, long-lived, and probably AI-based civilizations.

More good news for those who hope to make contact with aliens: the timeframe of when civilizations appear can be further narrowed to the last few billion years. There has been a bell curve in the rate of star formation, and we're past the peak of the curve. The curve peaked when the most sun-like stars existed in their mid to late stages of life. We know this because the rate of star formation in recent deep time is much lower than it used to be. If the rate were as high as it was billions of years ago, we would expect to see far younger stars compared to older stars, and we do not. It is likely that the rate of the evolution of civilizations with radio technology will mirror this bell curve, peaking a few billion years after the peak of star formation.

This civilization bell curve may play out like a thunderstorm. All of the elements for a heavy downpour begin to form, perhaps starting with a few sprinkles as the winds pick up speed. Even though the conditions are ripe for a heavy rain, it doesn’t arrive for a while. The rain is light at first, but then it begins to come down in sheets. The downpour may last for just a few minutes, or perhaps for many hours, but eventually it tapers off back to a sprinkle of droplets, and then ceases altogether.

This may be the historical picture of the rise and fall of civilizations in the galaxy. Humanity might be at the start of the tempest, and we are one of the first few drops before the downpour begins in earnest.

SUMMARY: A LONELY PALE BLUE DOT, PERHAPS ONE AMONG MANY

"We are a way for the Universe to know itself." – Carl Sagan

Possibly for the first time since the Universe began, matter and energy have come together in such a way as to be able to ask the ultimate questions about its existence: "What am I? How did I get here? Am I alone?"

Humanity lives in a unique moment in history. No civilization on Earth before us has experienced existence in quite the same way. The Mayans, Norte Chico, and Olmec never had our level of education, medicine, and security, not to mention the endless variety of entertainment options at the push of a button. If we could go back in time and experience what the lives of individuals in those early civilizations were like, we would probably be quite content to continue in the present with our air-conditioned homes and indoor plumbing.

Each one of us is a unique thread of existence woven into a vast tapestry called civilization. This tapestry of humanity tells the story of an entire species' monumental effort to understand and explore its place in the cosmos. All that we have ever learned is contained on this single planet in computer archives, shelved in vast libraries, painted on ancient cave walls, and shared through stories passed down from one generation to the next. This knowledge is worth preserving for future generations of explorers and great thinkers.

We have a duty to all who came before us to act now to counter the threat of countless events that would guarantee our swift destruction, and erase all of our great history. To ensure that as many of those threats as possible are mitigated, we need to keep developing new technologies, secure the world's infrastructure, and educate the public in science. The dinosaurs didn't stand a chance against the asteroid that struck them. Humans also almost went extinct before – some say we got down to just 40 breeding pairs – after the supervolcano Toba erupted 72,000 years ago.

In the past, humanity didn't have the capabilities to prevent or dodge these calamities. Now we do. A diversified residence in the Universe is the ultimate solution to not only humanity's quest for survival, but also our ability to expand our experiences. Residing on multiple worlds would significantly reduce the risk of any single event wiping out everything we have created in one catastrophic blow. The greatest realization of the lofty goal of colonizing space is that it is entirely possible to make happen. We only need the will and focus to get it done.

"Since, in the long run, every planetary society will be endangered by impacts from space, every surviving civilization is obliged to become spacefaring – not because of exploratory or romantic zeal, but for the most practical reason imaginable: staying alive." – Carl Sagan

Are there alien civilizations that have transcended the struggles that are a part of being an evolving species, and have successfully expanded beyond their home planet? We could learn from them, and perhaps they could learn a few things from us in return. The seeming emptiness of space would not be so empty if we knew of each other. If there are indeed other civilizations out there, it would be smart to present humanity in the best possible way. The scientists leading our quest into space are generally some of the brightest, most noble humans that can represent our ideals.

Although we may yearn for companions in the cosmos, we would be wise to not trust them too hastily. We could do without a stellar "frenemy" – or as they call it in French, *faux ami* – false friend. Wolves in sheep's clothing might catch us by surprise; we don't want to end up like the fools in *The Twilight Zone's* episode "*To Serve Man*." Feeling lonely might be an unfortunate consequence of being alone, but we might thank the heavens for the rather peaceful rapport with outer space which we have now. *Mieux vaut être seul que mal accompagné*, a French proverb, translates "It's better to be alone than in bad company."

If humanity one day ventures out to explore other star systems, only to discover worlds in ruin that once hosted thriving civilizations, then we should pay tribute to those civilizations and ensure they are remembered. Whatever evidence we can gather of their existence must be studied. And where an extinct civilization is found, a monument should be created there that preserves their identity and way of life, so that future generations can learn from their achievements, and their mistakes.

If dead worlds are indeed all that exists in our cosmic neighborhood, then perhaps we will have to adjust our hopes that a civilization could last for eons, and that we will ever be able to share our experiences with another intelligent species. We might have to accept that a more realistic goal for all civilizations is merely to live well and discover what they can, alone, in the time available to them.

Fate may yet deal us this most dire of cards as we attempt a journey to the stars. Someday humanity might fall back to a primitive society here on Earth, perhaps forever. If we at least did our best to establish a unified civilization that reached as far as it could into the depths of space, then maybe that is all that counts. Perhaps it will be some alien visitors eons from now that memorialize our once great civilization. They may honor the efforts humanity made to better itself and reach other sentient creatures that were indeed there, but just out of reach.

The ultimate quest then may not be to push forever forward one’s own potential, but to learn about and remember the dignity of others. It is my hope then that we will be remembered well.

NOTES

Is Anybody Out There?

1. I list here the 20% of stars being capable of hosting habitable planets. I must clarify two points here. First, any star could theoretically host a planet with life around it, if time and evolution were not a factor and the life just popped into existence on the spot. Because it takes at least a few million years for a planet to cool, let alone produce life, we can safely mark off the hot O, B, and A categories of stars. Assuming that life takes at least as long as it did to evolve on Earth, then even F type stars are in serious question. Of the 20%, I include G, K, and even throw in M type stars. M type are included because there are so many and they last for so long, that all of the other problems associated with them may still produce habitable worlds around some of these stars. Breaking it down, here are percentages for each star type that I estimate have a chance of producing a space faring civilization on one of their orbiting worlds:

    - O: 0%, B: 0%, A: 1%, F: 5%, G: 40%, K: 40%, M: 14%

While there are more K type stars in the Milky Way than there are G type, the smallest of the K type share a similar problem with all of the M types… their goldilocks zone planets (where liquid water could reside on the surface) may be tidally locked with their star. This effect is still a significant unknown in terms of habitability.

2. Project Ozma was started by Frank Drake in 1960. The project was considered the first attempt to search for extraterrestrials (E.T., i.e. aliens) in another star system. The famous Drake Equation was derived during a meeting in 1961. There was a follow-up experiment in the 1970s called Ozma II. Both experiments proved unsuccessful in detecting an alien civilization (as have all currently running experiments that now have far more sensitive equipment).
3. Robin Hanson has been a close study for this book throughout many of the chapters, but particularly for Chapter 9. He proposed The Great Filter in an essay in 1996. In the essay, he also referred frequently to the Fermi Paradox (he called it The Great Silence). I agree with The Great Filter concept, but here is where I disagree with Mr. Hanson on his conclusion as to why we haven’t heard from anyone. We haven’t found life and civilization yet because it’s simply difficult to find. We’re dealing with a needle in a haystack on a massive scale. There may be an abundance of life filled planets in the Milky Way, perhaps even billions. We may detect these worlds one day. The real question is civilization’s existence on these worlds, and how long they last. The answer to the Fermi Paradox and the Great Filter is quite simple; space and time are so vast, and civilization is so fragile, that we simply never meet each other in time. Billions of civilizations separated out by billions of kilometers and billions of years.
4. Oculus Rift, Vive, and Project Morpheus are all Virtual Reality goggles one wears to play virtual 3D games. These are new devices just being introduced to the game industry as of 2015. It has been suggested by many scientists that these VR devices will allow us to one day explore the cosmos in such detail as to feel like we are amongst the stars. Perhaps they are a prelude to my thoughts in Chapter 9 about alien civilizations eventually halting their exploration of the real cosmos in favor of a virtual one.
5. While I establish a couple of movie examples of a very possible scenario for our

demise through AI and robots, or of aliens, I feel that many view these movies as too literal of happenings sometime in our future. My personal view is that if we are ever to meet another race of any kind, it would likely be a friendly or cooperative venture. Life traveling through space is undoubtedly rare enough, and difficult of a challenge enough, to warrant that species ensuring its understanding of the need for cooperation and altruistic intentions with itself, and by extension with any other civilizations that it meets. Of course, there are scenarios we can still imagine where this outcome is not correct, so whatever my personal feelings on the matter, we should still be cautious about what we both create here on Earth, and expect to encounter in deep space someday.

6. Another spoiler note in how I feel about the fate of humanity. The scenario of a civilization's eventual fatigue in expanding out into space is in my view, given the vastness of space and time, the most likely scenario to occur for all civilizations that break through the great filter beyond natural and self-inflicted destruction. At some point, it is likely that civilizations will accomplish all that they want to accomplish, especially aided by any artificial intelligence they create. There may come a point for all civilizations where they end up idling in their own Matrix style virtual worlds, or simply regress to a more primitive state. Time has a way of changing things beyond the ability of those things to keep that change in check…

SUGGESTIONS FOR FURTHER READING

There are many topics in this excerpt that draw upon knowledge from many scientists and great thinkers. I encourage further reading into all of them. Here are a few related books that will give you an even bigger picture of our place in the cosmos:

Baggott, Jim. *Origins*. Oxford University Press, 2015.
Davies, Paul. *Are We Alone?*. UK: Penguin Books, 2015.
Davies, Paul. *The Eerie Silence*. UK: Penguin Books
Fichman, Frederick. *The SETI Trilogy*. Frederick Fichman, 2014.
Hawking, Stephen. *A Briefer History of Time*. NY: Bantam Dell, 2005.
Krauss, M. Lawrence. *The Greatest Story Ever Told…* Atria Books, 2017.
Nolan, Christopher. *The Science of Interstellar*. W.W. Norton & Comp., 2014.
Osgood, Don. SETI 2020: *A Roadmap for the Search for Extraterrestrial Intelligence*. Amazon.com, 2002.
Sagan, Carl. *Contact*. Pocket Books, 1998.
Sagan, Carl. *Cosmos.* Ballatine Books, 2013.
Savage, Marshall T. *The Millennial Project*. Empyrean Pub, 1993.
Stevenson, David S. *Under a Crimson Sun*. Springer, 2013.
Ward, Peter and Brownlee, Donald E., *Rare Earth: Why Complex Life Is Uncommon in the Universe*, 2000.
Webb, Stephen. *If the Universe is Teeming with Aliens…*, 2015.
Weir, Andy. *The Martian*. Random House, 2014.
Zubrin, Robert. *Entering Space…* TarcherPerigee, 2000.
Zubrin, Robert. *The Case For Mars…* Free Press, 2011.

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Alexander Wilszczan: http://bit.ly/1JTr9yy
Allan Telescope Array: http://bit.ly/1S4UtCb
Artificial Intelligence: http://bit.ly/1R7lUu8
Collision energy of space debris: http://bit.ly/1O1y3D4
Drake Equation for kids: http://bit.ly/1cpiQ6Q
Frank Drake history with Enrico Fermi: http://bit.ly/1WcD93Z
Oregon Trail: http://bit.ly/1p7oPLH
Radio communications travel distance: http://bit.ly/13onzcd
Search for exoplanet life: http://bit.ly/1ySMmNn
Size of Earth comparisons: http://bit.ly/1NuKTXl
Space resources: http://bit.ly/1MkNGoU
Star Trek: The Next Generation: http://bit.ly/1nczVOD
Super-Earth range of potential: http://bit.ly/IPMmvo
Super-Earth comparison to Earth: http://bit.ly/IPMmvo
Super-Earth surface gravity: http://bit.ly/1g1jqjh
Supernova rates: http://bit.ly/1OPPPcG
Travel to other star systems: http://bit.ly/1Rw1meP
Types of civilizations: http://bit.ly/1MNhODO

ABOUT THE AUTHOR

Mathew has been exploring the boundaries of what it means to be human since voluntarily stepping in wet cement while on the way to his first kindergarten class. The adventures and lessons learned since then have only become more unexpected and profound.

Mathew is currently a senior community manager in the computer game industry. He also studies physics, astronomy, and related areas, and often consults with game development studios on the topics found in this book. His goal is to raise everyone's awareness on why our existence as a civilization is so precious.

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