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"Where are they?": Fermi's Question and the Search for Intelligent Life

"If you will pardon so commonplace a simile, we have set off the fire alarm and have nothing to do but wait.

I do not think we will have to wait for long."

—Arthur C. Clarke, "The Sentinel" (Clarke 111)

In 1950, the distinguished physicist Enrico Fermi posed what has become known as Fermi's Question: "Where are they?" (Jones) Fermi was referring to other intelligent species in the universe. If other intelligent species exist, why have they not visited us yet? If other intelligent species do not exist, why are we alone? Fermi's three-word question has inspired almost 60 years of theories and speculation. To this day, no one has a scientifically certain answer to Fermi's Question. The theories that have been posed are, however, worth discussing, as they illustrate two different views of humanity; we are unique and special, or we are one of many species in the universe and there's nothing special about us.

Before we consider these two views, it helps to think about our expectations and why Fermi asked his question in the first place. The universe, depending on which theory of cosmology you subscribe to, is either infinite or finite but very, very, very large ("Is the Universe"). In an infinite universe, we can expect an infinite number of stars. With an infinite number of stars, we can expect an infinite number of planets. With an infinite number of planets, it is probable for at least some planets to have developed conditions favorable to life. Is it reasonable to think that there

would be more than one intelligent civilization in an infinite cosmos? In 1964, the astronomer Frank Drake proposed what became known as the Drake Equation to estimate the number of technological civilizations in our galaxy. The Drake Equation is given by:

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

where N is the number of technological civilizations expected, R* is the rate of formation of "suitable stars" (those with a large enough zone of habitation to support life), Fp is the fraction of those stars that form planets, Ne is the fraction of those planets that are capable of supporting life, Fl is the fraction of those planets that do develop life, Fi is the fraction of those planets that develop intelligent life, Fc is the fraction of those planets that choose to communicate, and L is the average lifetime of the civilizations on those planets ("The Drake Equation").

Frank Drake's initial set of assumed values for the Drake Equation were 10 suitable stars per year formed in our galaxy (R*), one-half of those stars (.5) forming planets (Fp), two of those planets being suitable for life (Ne), one of those planets evolving life (Fl), one-one hundredth (0.01) of those planets evolving intelligent life (Fi), one-one hundredth (0.01) of those choosing to communicate (Fc) and an average lifetime for civilizations of 10,000 years (L). This gives a value for N of 10 civilizations in our galaxy at any given time ("Basis"). With more conservative assumptions for these values, some of which are based on recent astronomical observations, the number goes as low as 0.00000008 possible civilizations in our galaxy at any one time ("Basis"). This still implies that, statistically, we should be able to expect at least one other civilization, and probably more, somewhere in the universe.

So, if our expectations are reasonable, and there should be other civilizations, we come back to Fermi's Question: "Where are they?" There are two major sets of theories that attempt to answer this question. The first set of theories is based on the idea that humanity is alone in the

universe; there are no other intelligent civilizations in existence. The second set of theories suggests that there are other intelligent civilizations and attempts to come up with possible explanations for the lack of communication from those civilizations. Each of these two major theory sets has a sub-set of possible explanations associated with it, which I will detail below. It is important to realize, though, that all of these theories are totally speculative. While some possible explanations may have more associated scientific evidence, no one can say for sure what the correct answer to Fermi's Question is, unless and until humanity does discover another intelligent civilization.

The first set of answers to Fermi's question is based on the premise that we have not heard from another intelligent civilization because we are alone in the universe. At first, this seems like an arrogant assumption; why should we assume that humanity is unique, or occupies a privileged position in the universe? Advocates of this theory suggest many possible reasons why this could be the case. We could simply be the first civilization to have evolved; it may take a minimum of 13.7 billion years for intelligent civilizations to form, and, if we wait long enough, we will eventually find other intelligence beyond Earth ("Possible"). Alternatively, it may be the case that the conditions allowing for life to evolve on Earth are unique to this planet, or at the very least extremely rare ("Fermi Paradox").

Additional sub-sets of this theory hold that there may be a narrow window during which technologically advanced civilizations attempt to communicate, and we may have missed this window. One possible reason for this may be that sufficiently advanced civilizations eventually lose interest in exploration or communications. Perhaps, at a certain level of advancement, these civilizations move from organic to non-organic (such as computer based) forms, and turn inwards ("Fermi Paradox"). Another, more pessimistic explanation, is that sufficiently advanced

civilizations eventually evolve the capability to destroy themselves, and invariably end up doing so before communicating with the rest of the galaxy ("Possible"). In other words, we have not heard from the aliens, because they've destroyed themselves before communicating with us.

An interesting aspect to this theory involves the anthropic cosmological principle. This principle has several variants. The "weak" variant basically states that, if the conditions that allowed for life to evolve did not exist, we wouldn't be here to observe that life does exist. In short, if we weren't here, we wouldn't be here to remark that we're here (Berger). This is almost tautological. The "strong" variant, on the other hand, argues that our presence is necessary for the universe to exist; that is, intelligent life is a necessary property for the existence of the universe, and a universe without intelligent life cannot exist (Berger). Taking the argument even further, the "participatory" variant argues that not only is intelligent life essential for the existence of the universe, but the universe itself can not exist without intelligent observers to bring it into existence (Berger). Finally, the "final" variant of the anthropic cosmological principle holds that not only is intelligence life essential for the existence of the universe, but that once intelligence evolves, it can not be destroyed, and tends to become more and more powerful (Berger). The "weak" variant sheds little light on this subject. The other three variants, however, imply that the existence of some sort of intelligence is necessary for the universe to exist; and that, if we did not exist, either some other intelligence would have to exist, or the universe itself would vanish. These theories are interesting to consider, but more philosophical than scientific.

The second set of theories holds that extra-terrestrial civilizations do exist and attempts to explain why they have not communicated with us yet. One possible set of explanations involves the nature of our technology. We assume that intelligent civilizations would be able to detect our existence by the radio emissions of humanity. These include those intended for communication

with other possible civilizations, through Search for Extra-Terrestrial Intelligence (SETI) projects, and the leakage of normal terrestrial broadcast signals, such as "I Love Lucy" re-runs. However, we have only been transmitting radio signals in an organized fashion for about 106 years. It may be the case that any civilizations out in the universe are more than 53 light years away. Since radio signals travel at the speed of light, it would take one-half that time for a signal to reach another civilization, and one-half that time for a return signal to come back. ("Possible"). It may also be the case that our radio signals are too weak to be detected by other civilizations ("Fermi Paradox"). Perhaps other civilizations have never evolved radio technology, and don't recognize our signals ("Fermi Paradox"). Or, if other civilizations did evolve radio, they've stopped using it by now and no longer monitor the radio frequency spectrum ("Fermi Paradox").

A second sub-set of possibilities involves barriers to communication. One argument is economics; perhaps other civilizations have found it too difficult and expensive to build technologies that allow attempts to communicate with other civilizations. These civilizations may have their own equivalent of Congress questioning the costs and benefits of trying to communicate with other, possibly non-existent, civilizations ("Fermi's Paradox II"). The speed of light may pose an insurmountable barrier to physical exploration. Could volunteers be found for a trip to our galaxy that might last hundreds of years at light speed? What would be the cost to that civilization to build the necessary transport? ("Fermi Paradox"). It may take even more sophisticated and expensive communications technology than humanity possesses to broadcast signals detectable by other civilizations ("Fermi Paradox"). It may also be the case that humanity is not listening hard enough for extra-terrestrial signals. SETI programs are not well funded; we may not be looking in the right place, or may not have sensitive enough equipment to detect low-

level signals from another civilization (“Fermi Paradox”). We may also not recognize some signals as being from intelligent species. Our current SETI programs are based on broadcasting messages that encode concepts, such as mathematics, that we consider to be universal. What if this isn’t the case? What if different species have evolved different mathematical concepts, and we don’t recognize what they’re trying to tell us? (“Fermi Paradox”) Finally, it may be the case that other civilizations are not communicating with us because they have nothing to say to us (“Possible”). If we are to them as humanity is to one-celled organisms…well, what do you have to say to an amoeba?

Another sub-set of this theory suggests that other civilizations are communicating. It may be the case that they have decided humanity isn’t the intelligent species on this planet, and they are communicating with dolphins, or some other species. (“Fermi Paradox”) A second possibility is that the aliens are not only communicating with us, but are actually on Earth, and have chosen to hide themselves until conditions seem right (“Fermi Paradox”). The British author David Icke suggests that almost all world leaders, and many other prominent figures, are actually shape-shifting extra-terrestrial reptiles (“David Icke”). Yet another theory is that we, ourselves, are the aliens. Perhaps there are multiple galactic civilizations, all related, and all seeded on different planets from a common source (“Possible”). It may be that, at some point, the civilization that planted the seeds will come back to check up on us, and welcome us into full membership in their civilization.

This leads into yet another set of theories, mostly based on the idea that our isolation is deliberate. One possible theory is that we are the property of some other species. Basically, this would make us the cosmic equivalent of cattle; and, at some point, our owners are going to show up and take humanity to the “last round up” (“Possible”). Still another theory suggests that we

are in some form of quarantine. Perhaps other civilizations have determined that the human race is currently too dangerous to interact with the rest of the civilized galaxy, and are just waiting for us to reach a sufficient level of social or technological advancement before lifting the quarantine order ("Possible"). Alternatively, we may be under some form of non-intervention order; perhaps other civilizations have been ordered not to contact us, for fear that they might interfere in our development ("Possible"). It may also be the case that other civilizations are waiting for a sign from us that we've reached a certain level of advancement (Clarke's "cosmic fire alarm") and, once they get that sign, will show up and make us a full part of the "galactic confederation."

There is a final set of miscellaneous theories. Perhaps the aliens are attempting to communicate with us, but we don't recognize the technology they're using ("Fermi Paradox"). As Arthur C. Clarke once said, "Any sufficiently advanced technology is indistinguishable from magic." ("Clarke's Three Laws") Maybe the aliens are manipulating particles at the quantum level, and we don't have the knowledge to detect this at the present time. The physicist Freeman Dyson has suggested that the energy demands of an advanced civilization are so large, the only way to meet them is to build a giant structure (a "Dyson sphere") around a star and live on the inside of the structure ("Fermi Paradox"). What would such a structure look like to us, and would we even recognize it as a sign of an advanced civilization? Alternatively, perhaps intelligent civilizations do exist, but for some reason are non-technological ("Possible"). A final theory is that the intelligent civilizations in the galaxy are not making their presence known for a good reason; the existence of a "cosmic destroyer" that goes around destroying any civilization that it detects ("Possible"). Perhaps we haven't received the warning message yet, and the "cosmic destroyer" is on the way.

Ultimately, Fermi's Question is impossible to answer at our current state of knowledge. We won't know for sure until the aliens show up, if they ever do. However, the question serves to illustrate two distinct ways scientists look at the universe. Humanity is special and unique, and there's nobody in the universe but us chickens, or humanity is not special and unique, we live in a universe of other intelligent civilizations that have chosen not to communicate with us yet, and intelligent life goes on even if humanity don't. It is tempting to classify these two viewpoints as "optimistic" and "pessimistic", but which is which? Are we optimists if we say, "There's a whole big universe out there just for us. Let's go!" Are we pessimists if we believe humanity is replaceable? Like Fermi's Question itself, there are no good universal answers.

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