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ASTROBIOLOGY AND THE SEARCH FOR LIFE ON OTHER WORLDS

Finding intelligent life has always been a major dream for all space scientists. The idea of extraterrestrial life contacting us is a fascinating concept that has filled our dreams and science fiction novels since the first telescope was used. The attempts to find intelligence off Earth are collectively known as SETI, or the Search for Extraterrestrial Intelligence.

The largest projects use the idea that electromagnetic radiation as communication can be used as a form of contact from an intelligent extraterrestrial source.

The basis behind this theory is the fact that these radio waves tend to move in a rather uniform pattern that can penetrate most atmospheres. Broadcasting these waves would be an efficient source of interplanetary communication. Electromagnetic radiation is a reliable way to contact potential intelligent life. For one, waves created by man-made devices such as the television, radio, and other appliances could be detected from space and the waves could be identified from natural waves hinting that they come from an intelligent source. Current SETI projects and future ideas include the constant transmitting of a signal that could be detected by an extraterrestrial source, as well as the development of a message in a ‘universal language’ that is one of friendship that could be delivered to an alien source upon contact.

Due to the fact that intelligent life requires a certain environment, a lot of areas in our known universe can be removed from the list of those which might house extraterrestrial life in a form other than bacteria. The first requirement for a place to be a specimen for housing life is it to fulfill what is referred to as Circumstellar habitable zone, or more commonly known as the 'Goldilocks Conditions'. These conditions state that a place that would support life requires the 'just right' amount of each aspect crucial for life. The temperature must not be too hot or too cold, the atmosphere needs to be just right, and the acid-base concentration of the life sources must be perfect, and so on. These planets come rare, due to the fact that it needs to be in a constant orbit near a star such as our sun that would provide heat, as well as have an atmosphere similar to ours. The best candidates for life so far seem to be planets that resemble Earth in some way, shape, or form. Amazingly, some gas giants seem to be able to fit the characteristics of these conditions, and some are hypothesized to have oceans of liquid water that may house life, although most probably non sentient. Candidates for life close to our planet Earth are found among the many moons of Jupiter, such as the oceans of Europa, the probability of life on Titan and its rains, and the mystery of the massive asteroid Enceladus which may hold the key to life. However, most of this life is hypothesized to be bacterial, microbial or a small, non sentient species such as a fish relative. Although many planets have been hypothesized to fulfill the Goldilocks requirements, they are not within the range of current space probe exploration, and can only be photographed. It is also a main goal of scientists to explore moons, due to the fact that they largely outnumber planets, a great many contain water, and they are also affected by tides. This can be seen in the many moons of Jupiter, great candidates for life.

One of the greatest mysteries today is the lack of any communication with an intelligent alien species, even though the universe appears to be filled with an enormous amount of places where life could exist (by some theories an *infinite* amount). This weird circumstance is known as the Fermi Paradox, named after scientist Enrico Fermi as he is one of the first to consider this question seriously. One way astronomers have attempted to approach this problem is through the use of the Drake Equation. This estimation tool was developed by Frank Drake in 1951, but has since been revised. The original equation takes into account the average number of stars formed per year, the number of stars that have planets, the number of planets which are assumed to be within the Habitable Zone, the number of planets that could harbor life actually developing life, the fraction of those forms of life being intelligent, the number of those civilizations that would develop technology that could be detectable from Earth, and the length of time those civilizations would last for. Many have criticized this however, for being far too vague. Original estimates would put the range of these civilizations from 1 000 to 100 000 000, and yet this goes against our observations thus far. Modifications have been made to the original estimate however, but these have, for the most part, just made the equation less reliable via the inclusion of new variables that may be even more difficult to estimate. These include the chance of intelligent life appearing on a planet after it had already destroyed itself, the chances extraterrestrials would have the ability and the drive to broadcast radio waves or by other means so we could discover them, and the chance that some planets may have been colonized by spacefaring species. Actual solutions to the Fermi paradox each have their pros and cons. One is the Rare Earth Hypothesis, which brings up the possibility that life, or at least just ‘intelligent’ life may really be rare and we are alone. Although this is fairly straightforward, the assumption that we are truly alone in the vastness of the universe seems very self-centered, and an easy way we can dodge the question. One of the more whimsical suggestions that has been brought up in this discussion is that the planet Earth is similar to a sort of ‘planetarium’ or ‘zoo’ for another type of species (or species) They may wish to only make a face-to-face encounter with human beings if they have proved themselves to be deemed worthy enough for one, or may be flat out denied a meeting forever. This seems unlikely because it assumes that aliens would be very similar to us, (likeing planetariums and zoos), and would only bring forward the problem of how unlikely it would be that we just so happened to be the random species they would choose to be in their ‘zoo.’ Another idea that has been proposed is the possibility that intelligent life never lives long enough for it to do leave any detectable trace of their existence. This does seem plausible, as we humans have developed the means to completely annihilate ourselves multiple times over (through the use of nuclear weapons, or biological/chemical weapons that could be deployed in warfare). While we could assume that aliens may also have means of destroying themselves (possibly even a very similar fashion) it is a very dreary way to look at things and, again, is an unlikely scenario which relies on the same thing occurring to <u>all</u> intelligent civilizations, one that we are not so sure we can make. One of the hypotheses that we found most interesting was that we just have not been searching for long enough. This seems like a very likely idea, as we have not dedicated much of our time to looking since the past century, and even then the Search for Extraterrestrial Life has received an astonishingly little amount of international support. Besides the chance that we have surveyed an infinitesimal patch of the sky for intelligent, life and we have searched each spot on it for a comparatively infinitesimal period of time, even if life is abundant in the universe it would seem very luck if we would have been able to discover it by the present day. This short period of time also shapes our way of searching in the first place, leaving it probable that our methods are fundamentally flawed. We have the expectation that if we were to ever receive any messages that we would be able to pick them up at radio observatories that have been set up. Our only real reason for expecting this is that it would be how *we* would broadcast our presence to the cosmos at this place in time. We have no way of looking into the future and seeing that there would be a much easier way to communicate, or that life unlike our own would communicate among themselves in a way that could not be conveyed through radio frequencies. Another equally possible situation is one in which other forms of intelligent life quickly become uninterested in trying to search for others. At some point in the evolution of an alien civilization, it may seem unnecessary to do so, them finding more enjoyment in simply keeping to themselves or uploading their consciousnesses inside their own forms of computers. They may be so advanced that they could not possibly ever learn anything from a contact with us, or could even see us as not falling within their range of 'sentient.' On the other end of the spectrum, it could be seen that other types of life would stop communicating out of fear. If some extraterrestrials are in any way violent, others that exist would soon go quiet or risk being destroyed as they are seen as a threat to a more advanced alien civilization.

Other Forms of Life:

While much of the search for life beyond Earth, and much of the thought of what extraterrestrial life would be like ties to forms that are nearly identical, or at least are within the ballpark of life on Earth. Some of the key features that we tend to be looking for are connected to the presence of carbon (and other essential elements that compose DNA), an Earth-like temperature, and, perhaps most importantly, liquid water.

One element that is a good candidate for replacing carbon in alien forms of life is silicon. Being in the same group on the Periodic Table, it has many of the same properties as carbon, without being different to it in terms of mass. The study of silicon based life, however, is not very widespread due to many different factors. One is the sheer lack of silicon in space, at least compared to carbon. Due to its much larger mass, only some stars are able to form it, leaving carbon to be much more abundant throughout the universe. It has been confirmed that this difference is nearly ten-to-one, making it seem a much better prospect to search for carbon-based life out of sheer probability. Other problems with silicon-life have arisen as well. It produces overall weaker long-chained molecules, which are essential for every single polymer used by the human body. In addition, a lot of the smaller compounds that silicon readily forms can be reactive or insoluble in water, making a form of life using both extremely unlikely and again pointing towards the use of carbon as one of the basic building blocks for life in the universe. Just because silicon is the most used idea for a replacement for carbon in living systems, there are still theories (however they are usually more unlikely) that would replace it with another element altogether. Boron, Sulfur, and Oxygen have also been considered by the scientific community, but we saw that these elements suffered some of the problems that silicon did, and sometimes problems that are much worse. Boron is rarer in the universe than even silicon, and all three are generally very volatile and would not easily be useful except under very specific circumstances (some not being within the range where liquid water even exists).

Another element that has been theorized to be possible to be replaced in some exotic forms of life is phosphorous. The only real candidate for this replacement is arsenic. While this element is extremely poisonous to most life on earth, it is only this way because the body is easily tricked into thinking it is phosphorus, replacing it in DNA. Most organisms die because they are not used to this change in size, although arsenic is in the same group on the periodic table. However, one interesting thing is that not all life on earth will die from exposure to arsenic. One form of organism has evolved to survive even after this phosphorus-arsenic switch has occurred, living in a lake that has a high concentration of the supposedly deadly poison. Even though this prokaryote certainly does not thrive in such conditions, it does show that life is able to continue with arsenic instead of phosphorus (especially when billions of years of evolution on a foreign planet are taken into account when considering its possibility).

The biggest consideration when it comes to life not as we know it is the substitution of what seems most essential to life, liquid water. Almost all of humanity's search for life beyond Earth has revolved around this search for liquid water. This is because its components are very common throughout the universe, and water has a place as being describe as a 'universal solvent' because it is so versatile when it comes to dissolving all of the compounds that are necessary for life on Earth to exist. The hunt for liquid water on other worlds has placed a huge limiting factor when it comes to planet hunting, the only planets even considered to have the possibility for harboring any form of life must reside within the narrow Goldilocks Zone. This leaves out anything other than terrestrial planets as well. Some gas giants, moons, and even asteroids could hold an exotic form of life that is completely excluded because it has been ruled out from containing liquid water on its surface.

The highest likelihood of replacing water goes to liquid ammonia. One of the biggest things that liquid ammonia has going for it as a water substitute is the fact that, like water, it is composed of elements that are found in abundance throughout the universe (hydrogen and nitrogen). It has many other similarities to water other than this as well. Water serves a main purpose in biology as being a solvent for almost all chemical reactions involved with life, and ammonia is also able to readily dissolve most organic molecules. One other similarity is its neutrality on the pH scale. Like water it satisfies the qualities of being both an acid as a base because it is able to be both a proton donor as well as a proton acceptor. This prevents any of the effects that could possibly arise from having a too acidic or too basic substance for which the biology of life to take place. One of the major obstacles to the formation of life based upon ammonia instead of water is the fact that water has extremely strong hydrogen bonds in comparison to most other compounds, including ammonia. Some of the properties of water that relate to this on Earth (surface tension, tendency to require a large amount of energy absorbed or emitted to change temperature, etc.). Any life based on ammonia would most likely not appear in the Goldilocks Zone, as its main purpose is to weed out where planets are likely able to have liquid water. Ammonia based life would instead exist much farther away from a star in a solar system, and it leaves open the possibility of it being on a body such as a moon, instead only being able to be found liquid in large quantities on planets, as water does.

Another substance that could easily take the place of liquid water in terms of its central role in life would be liquid methane. Some of the same properties that make methane ideal for replacing water (and some of its drawbacks) also can be seen in other hydrocarbons. While methane is a decent solvent of organic compounds, it does fall short to water and even ammonia at doing this. Even though this is true it seems as if it would act enough to serve at least this function. It also differs from liquid water as it has weaker hydrogen bonds and is less reactive. These could be seen as pluses however. Although many of life's processes on Earth do require these traits of water, methane's lack of these traits allows for some processes to work at lower temperatures and would not break down organic molecules, allowing a lot of extra time for life to come into existence on a world containing it.

The proposal that methane is a possible replacement from water has a far greater ground in reality than ammonia does however. There has recently been strong evidence towards Titan, Saturn's largest moon having life. The temperatures on the moon prevent the formation of liquid water, but the surface does have liquid methane.

Stellar Migration The future of human and Earthbound life is a matter of pressing significance in astrobiological community. Considering the recent exponential growth rates of human populations in recent years, colonization of other celestial bodies seems a necessity in order to facilitate humanity's continued expansion. Although a number of theoretical methods of long-distance space travel exist, none are currently feasible and some may never be. Conventional means of travel to other stars is simply unfeasible. Even at the speed of light, spacecraft or other vessels would take many years to reach even the closest of stars and millennia for others. Thus, the ship would have to be self-sustainable, which in the vast emptiness of space is total. It would also likely have to cycle through a number of crews, and force the children of spacecraft personnel to serve upon the same ship as their parents. As such, such means of travel would not only be impossible but also likely lead to violations of human rights. A more popular and well-known method is the use of Cryonic technology to preserve the bodies of travelers long past their natural lifespan in order to undertake the massive lengths of time journeys to other stars would require. Normally, exposure to low temperatures would rupture the cells, freeze the blood, and ultimately cause the death of the victim. However, future Cryonics technology will theoretically employ the use of nanomachines to repair the body one molecule at a time, resulting in complete restoration; the same concept is put to effective use in hypothermic surgery. However, while this has the possibility of working, more effective methods could be used. Cryonics requires that the body be transported, which in turn requires space on the craft, and energy in order for the Cryonics process to work. Large spaceships of today have only a few crewmembers on board yet are massive in size, and so to transport any large number of personnel for the purpose of colonization would be simply ludicrous. Thus, Cryonics, while feasible for smaller trips with fewer personnel, cannot function effective in large-scale migration and thus should be restricted to the realm of medicinal use. The most feasible form of space travel would quantum teleportation, although it is likely centuries away from practical usage. This works through the phenomenon of quantum entanglement, in which certain particles across the universe are inexplicably linked and take on the same values as their match. By controlling quantum entanglement, it is possible to transmit information over vast distances instantaneously; in 2012 Chinese scientists were able to teleport a photon 97 kilometers through this method. This most obviously opens up the possibility of creating "ansibles", instantaneous communication devices of science fiction fame. However, it can also lead to space travel for life on Earth. This would require the ability to transfer the human consciousness into computer code, a process that is estimated to become possible in half of a century. This information could then be transmitted instantaneously between stars, along with the code necessary to assemble a body at the destination point, or alternately enter an awaiting receptacle such as an electronic brain. Initial colonists may require such a receptacle to be in place already, in order to terraform unsuitable planets for human life. While such forms of travel may be dismissed as science fiction at present, it is completely possible in the future and is likely the most effective means of migration through space possible to human kind. The same principle, on a more basic level, could also be used for non-sentient Earth life, such as flora and fauna. Adaption to Other Planets In order for life to spread off of the planet of its origin, it must have conditions in which it can survive on the planet it migrates to. This is the main reason why humans are not living on other planets in the modern day. Thus, in order for human and Earthbound life to spread to other planets, either a planet with benevolent conditions must be found or alternately something must be changed such that known planets can support life as we know it. The latter can happen in one of two ways: something can change on the planet such that it becomes able to support life, or the life itself must changed such that it can live given the planet's conditions. Changing the conditions on another celestial body such that they becomes similar to that of Earth is known as terraforming, and is one possible method of allowing colonization of other planets and the furthering of human life. At present, it is in fact considered possible with modern technology to do so, but would require a larger amount of resources than any organization is currently willing to put forth. The first step in terraforming a planet such as Mars, for example, would be to permeate the subject's atmosphere with a large amount of greenhouse gases in order to artificially create a global warming effect on the target planet. Such gases, namely chlorofluorocarbons, could be manufactured in massive amounts by automated factories on the surface of the planet, through processing the air and soil of the planet. Although it would take time, this process would eventually melt the polar ice caps of Mars, and according to NASA, raise the average temperature of the planet by as much as 70 degrees Celcius. As the polar ice caps theoretically contain water, this would cause bodies of water to form on the surface of Mars, creating a water source for the planet as well as changing the atmospheric pressure to a survivable level. Finally, importation of Earth fauna would be necessary in order to produce oxygen. While this process may take centuries, it would eventually result in Earth-like conditions and allow life from Earth to live without modification of itself. While at the present the amount of funding required is exorbitant causes this process to be economically impossible, future technology and necessity may change this situation, and make it quite desirable to terraform other planets to sustain human life. An alternate method of surviving on other planets requires the altering of the body's needs and capabilities. Common issues posed by other planets include atmospheric composition, extreme climates, and lack of basic necessities for life such as water. Thus, through modification of the current human body or creation of artificial bodies, humanity or other forms of life could overcome such obstacles and successfully live on planets normally unsuitable for them. This again connects back to the idea of converting the consciousness of sentient forms of life into information that can be processed electronically. Such technology would allow humans on Earth to maintain total control over or even transfer their awareness to automaton technology on other planets, and allow these controllers to become pioneers for posterity. The same principle could be applied to simply create synthetic bodies that do no require the basic needs of life as we know it, and in essence force artificial evolution to rapidly occur. Such bodies would need to rely on an alternate source of energy for their continued operation; thus, application of fusion technology could find a successful niche in this field, as it would function properly on any planet with matter. As such, forced adaption of the human or alien self could be an effective means of propagating the expansion of life on Earth or other planets. The Next Step A question that has been posed over and over again throughout history is "What is the next step in the evolution of life?" Various researchers hold different opinions as to what exactly this change will be, but it is certain that in some way it will occur. This point is when life reaches a singularity, a point where it is unrecognizable to what it once was; whether humanity will face a technological or organic singularity remains to be seen. In regards to a technological singularity, the formation of a collective mind or minds is one of the most likely outcomes. Components of such a system would be individual humans, gathered in a large number and constantly sharing information. Such an advancement would require transfer of consciousness to information technology, but would result in such processing power that it would lead to exponential development in all fields. Such a system is already speculated by psychologist Carl Jung to already exist on a minor level, in the form of the collective unconscious. This results in the base tendencies, reactions, and attitudes of humans and other forms of life across the planet, regardless of upbringing. Ample examples exist, ranging from the mother-child relationship to reactions to trauma and failure; such points are universal in nature, and hint at an unconscious connection already existing between humans at present. The next step, then, is to create a conscious form of this connection, for the sharing of information and experience instantaneously. If humanity were to take this step, its base structure would likely change, as a large percentage of current facilities and utilities would become obsolete overnight. Training programs could be done instantaneously, allowing mastery of disciplines in all fields of life and further accelerating development. Human limitations would be cast aside, as any and all problems could be solved by the collective of minds. Thus, such collectives would rapidly become powerful entities, condemning those who abstain to obsoletion, albeit indirectly. Whether it is beneficial or malevolent, this development is definitely a possibility in the future of life and would transform basic life into something wholly different from its present state. An alternative possibility for the future of life is for it to reach an organic singularity, a point where its past self will no longer recognize its future self as of the same species. Current living conditions in much of the world can be seen as responsible for this; as the quality of life and life expectancy increase, the effects of Darwinian theory and natural selection decrease, effectively creating a genetic fan in which the subject species, humans in this case, genetically spread out as mutations no longer pose a serious impact on the likelihood of survival. In the 21st century, more and more children with special needs can survive than ever before. A few hundred years ago, this was not the case, and such mutations would be destroyed before they could propagate. However, in a society where natural selection has minimal impact, more and more mutations can survive and reproduce. Thus, millions of years in the future, humanity or other affected species could branch off into numerous different species, all sentient, yet entirely different from their previous self. This process results in genetic diversity, for better or for worse, and would render present humanity incapable of recognizing its descendants. This is not restricted to humanity, and can quite possibly have occurred to alien forms of life that have reached such a point in their civilization. Genetically, this is most likely the next step for advanced races such as humanity.

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