DOWNLOAD PDF WILL THE SEARCH FOR EXTRATERRESTRIAL LIFE EVER SUCCEED?

Chapter 1 : Life in Space - Search for Extraterrestrial Intelligence

The Search for Extraterrestrial Intelligence (SETI) has been dominated for its first half century by a hunt for unusual radio signals. But bold new innovations are required if we are ever to hear.

Should we call out to space aliens? To speed the search for extraterrestrials, some scientists recommend sending signals to space Ilima Loomis Mar 21, â€" 7: Now some have proposed we try broadcasting a welcome call. Not everyone, though, thinks that is a good idea. Ever been to a party and wondered why no one was talking to you? For more than half a century, astronomers have been listening to space. They use powerful radio telescopes, hoping to pick up signals from civilizations in distant space. So how can we get the conversation started? They think Earthlings should start beaming signals out into the universe. He supports the idea. Do we really want to shout out to whomever will listen: Come invade our planet! At the very least, these scientists argue, people should discuss the idea and decide as a species whether we should try to actively put ourselves onto the radar screen of more technologically advanced beings. But it could be that one percent of them are aggressive Klingons. He also is one of those people who argues that Earthlings should proceed with caution. Broadcasting powerful signals would change the nature of our planet. It would make Earth more observable from space. Other projects must go through an environmental review, he says, and this should too. Yet plenty of researchers are taking this idea quite seriously. The discovery that there are actually billions of other planets in the universe led many scientists to believe that extraterrestrial life probably exists. There are probably billions of them in the universe. Biology also has turned up plenty of life on Earth that can survive and thrive in extreme environments â€" conditions that once were thought uninhabitable. These include places that are very hot, very cold, very dry or even bathed in acid. These are not too hot or too cold â€" but just right to sustain liquid water somewhere. Goldilocks zone Whatever such alien life might be like â€" even if most of those organisms are just algae or worms â€" some would likely be intelligent, Grinspoon suspects. And some of them probably have much more advanced technology than we do. Scientists have a few ideas. Like a message in a bottle, people could put something into a capsule and shoot it into space. Or scientists could flash lights at the aliens, training the beams of super-powerful lasers at nearby star systems. Think of it like Boy Scouts waving their flashlights at girls who might be camping on the other side of a lake. Researchers would send radio broadcasts out across the vast expanses of space. What is a laser? In addition to other ideas for sending out signals, he recommends beaming radio messages at other stars with huge radio telescopes, like the Arecibo Air-eh-SEE-boh observatory in Puerto Rico. Right now, Arecibo uses radar to probe our solar system. The telescope sends out a pulse of radio waves. How long it takes those signals to bounce off things, such as asteroids, tells us how far away those things are. Meeting a more advanced culture could give our species a new perspective about life on Earth, says Vakoch. It might also show us new tools to solve Earthly problems, he adds. Brin sees it a bit differently: He advises that they think and talk it over before deciding what to do next. If we do contact aliens, studying our own history might give us ideas about ways to keep our interactions peaceful. This should be something we study, not something we avoid. Supporters of active SETI point out that FM radio and television signals both emit a high enough frequency that they could be picked up in space. Then there are all of those signals flying around between satellites, and those powerful radar pings from telescopes like Arecibo. While people debate the issue, maybe the aliens are already watching our TV shows and listening to our music, says Philip Lubin. It would beam out more powerful signals, focusing them on the closest star systems. In that case, he cautions: He does, however, agree that society should talk openly about the search for extraterrestrial life â€" and decide what to do if aliens respond. Tell other scientists so they can confirm the discovery. But Vakoch would like to see those policies debated and agreed to by the United Nations. The only solution to those problems is to learn how to think and act not as different races and countries, but as one species, he says. As aquatic organisms, they grow in water. Like green plants, they depend on sunlight to make their food. Most orbit in a region that falls between the orbits of Mars and Jupiter.

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Astronomers refer to this region as the asteroid belt. The scientists who study them are known as biologists. A farmer may broadcast seeds by flinging them by hand over a large area. A loudspeaker may send sounds out over a great distance. An electronic transmitter may emit electromagnetic signals over the air to a distant radio, television or other receiving device. And a newscaster can broadcast details of events to listeners across a large area, even the world. It can happen naturally or in response to human activities, including the burning of fossil fuels and clearing of forests. Culture is passed on from generation to generation through learning. Once thought to be exclusive to humans, scientists have recognized signs of culture in several other animal species, such as dolphins and primates. Environment may refer to the weather and ecosystem in which some animal lives, or, perhaps, the temperature, humidity and placement of components in some electronics system or product. An abbreviation made famous by the Universal Pictures movie, E. The main character was a charming space alien called E. In physics The number of wavelengths that occurs over a particular interval of time. Lasers are used in drilling and cutting, alignment and guidance, in data storage and in surgery. In the United States, they are also known as Indians. In Canada they tend to be referred to as First Nations. To accomplish the third feat, the object must be big enough to have pulled neighboring objects into the planet itself or to have slung them around the planet and off into outer space. Based on that definition, IAU ruled that Pluto did not qualify. The solar system now includes eight planets: It works by sending out periodic radio waves that bounce off of the object and then measuring how long it takes that bounced signal to return. Radar can detect moving objects, like airplanes. It also can be used to map the shape of land â€” even land covered by ice. Longer than the waves of visible light, radio waves are used to transmit radio and television signals; they are also used in radar. The plots in many of these stories focus on space travel, exaggerated changes attributed to evolution or life in or on alien worlds. Stars develop when gravity compacts clouds of gas. When they become dense enough to sustain nuclear-fusion reactions, stars will emit light and sometimes other forms of electromagnetic radiation. The sun is our closest star. Some, however, collect radio emissions energy from a different portion of the electromagnetic spectrum through a network of antennas. Terra is Latin for Earth. All things that exist throughout space and time. It has been expanding since its formation during an event known as the Big Bang, some

Chapter 2 : If we discover extraterrestrial life, what happens next? | Science | The Guardian

Ever since we invented radio, the search for extraterrestrial life has been a legitimate scientific inquiry. The reason some laugh at the pursuit is because the odds of success have always been.

This originally appeared in The Bioastronomy News, vol. By Ernst Mayr What is the chance of success in the search for extraterrestrial intelligence? The answer to this question depends on a series of probabilities. I have attempted to make a detailed analysis of this problem in a German publication Mayr and shall attempt here to present in English the essential findings of this investigation. My methodology consists in asking a series of questions that narrow down the probability of success. Even most skeptics of the SETI project will answer this question optimistically. Molecules that are necessary for the origin of life, such as amino acids and nucleic acids, have been identified in cosmic dust, together with other macromolecules, and so it would seem quite conceivable that life could originate elsewhere in the universe. Some of the modern scenarios of the origin of life start out with even simpler molecules--a beginning that makes an independent origin of life even more probable. Such an independent origin of life, however, would presumably result in living entities that are drastically different from life on Earth. Obviously, only on planets. Even though we have up to now secure knowledge only of the nine planets of our solar system, there is no reason to doubt that in all galaxies there must be millions if not billions of planets. The exact figure, for instance, for our own galaxy can only be guessed. There are evidently rather narrow constraints for the possibility of the origin and maintenance of life on a planet. There has to be a favorable average temperature; the seasonal variation should not be too extreme; the planet must have a suitable distance from its sun; it must have the appropriate mass so that its gravity can hold an atmosphere; this atmosphere must have the right chemical composition to support early life; it must have the necessary consistency to protect the new life against ultraviolet and other harmful radiations; and there must be water on such a planet. In other words, all environmental conditions must be suitable for the origin and maintenance of life. One of the nine planets of our solar system had the right kind of mixture of these factors. This, surely, was a matter of chance. What fraction of planets in other solar systems will have an equally suitable combination of environmental factors? Would it be one in 10, or one in , or one in 1,,? Which figure you choose depends on your optimism. It is always difficult to extrapolate from a single instance. This figure, however, is of some importance when you are dealing with the limited number of planets that can be reached by any of the SETI projects. Physicists, on the whole, will give a different answer to this question than biologists. Physicists still tend to think more deterministically than biologists. They tend to say, if life has originated somewhere, it will also develop intelligence in due time. The biologist, on the other hand, is impressed by the improbability of such a development. Life originated on Earth about 3. If Earth had been temporarily cooled down or heated up too much during these 3. When answering this question, one must be aware of the fact that evolution never moves on a straight line toward an objective "intelligence" as happens during a chemical process or as a result of a law of physics. Evolutionary pathways are highly complex and resemble more a tree with all of its branches and twigs. After the origin of life, that is, 3. These bacteria and their relatives developed surely 50 to different some perhaps very different lineages, but, in this enormously long time, none of them led to intelligence. Owing to an astonishing, unique event that is even today only partially explained, about 1, million years ago the first eukaryote originated, a creature with a well organized nucleus and the other characteristics of "higher" organisms. From the rich world of the protists consisting of only a single cell there eventually originated three groups of multicellular organisms: But none of the millions of species of fungi and plants was able to produce intelligence. The animals Metazoa branched out in the Precambrian and Cambrian time periods to about 60 to 80 lineages phyla. Only a single one of them, that of the chordates, led eventually to genuine intelligence. The chordates are an old and well diversified group, but only one of its numerous lineages, that of the vertebrates, eventually produced intelligence. Among the vertebrates, a whole series of groups evolved--types of fishes, amphibians, reptiles, birds and mammals. Again only a single lineage, that of the mammals, led to high intelligence. The mammals had a long evolutionary history which began in the Triassic Period, more than million years ago, but only in the latter part of the Tertiary Period-- that is, some 15 to 20 million years ago--did higher intelligence originate in one of the circa 24 orders of mammals. The elaboration of the brain of the hominids began less than 3 million years ago, and that of the cortex of Homo sapiens occurred only about , years ago. Nothing demonstrates the improbability of the origin of high intelligence better than the millions of phyletic lineages that failed to achieve it. How many species have existed since the origin of life? This figure is as much a matter of speculation as the number of planets in our galaxy. But if there are 30 million living species, and if the average life expectancy of a species is about , years, then one can postulate that there have been billions, perhaps as many as 50 billion species since the origin of life. Only one of these achieved the kind of intelligence needed to establish a civilization. To provide exact figures is difficult because the range of variation both in the origination of species and in their life expectancy is so enormous. The widespread, populous species of long geological duration millions of years , usually encountered by the paleontologist, are probably exceptional rather than typical. Adaptations that are favored by selection, such as eyes or bioluminescence, originate in evolution scores of times independently. High intelligence has originated only once, in human beings. I can think of only two possible reasons for this rarity. One is that high intelligence is not at all favored by natural selection, contrary to what we would expect. In fact, all the other kinds of living organisms, millions of species, get along fine without high intelligence. The other possible reason for the rarity of intelligence is that it is extraordinarily difficult to acquire. Some grade of intelligence is found only among warm-blooded animals birds and mammals , not surprisingly so because brains have extremely high energy requirements. But it is still a very big step from "some intelligence" to "high intelligence. As one scientist has suggested Stanley , it required complete emancipation from arboreal life to make the arms of the mothers available to carry the helpless babies during the final stages of brain growth. Thus, a large brain, permitting high intelligence, developed in less than the last 6 percent of the life on the hominid line. It seems that it requires a complex combination of rare, favorable circumstances to produce high intelligence Mayr As stated, rudiments of intelligence are found already among birds ravens, parrots and among non-hominid mammals carnivores, porpoises, monkeys, apes and so forth , but none of these instances of intelligence has been sufficient to found a civilization. The answer quite clearly is no. In the last 10, years there have been at least 20 civilizations on Earth, from the Indus, the Sumerian, and other near Eastern civilizations, to Egypt, Greece, and the whole series of European civilizations, to the Mayas, Aztecs, and Incas, and to the various Chinese and Indian civilizations. Only one of these reached a level of technology that has enabled them to send signals into space and to receive them. This is by no means certain. Even on Earth many groups of animals are specialized for olfactory or other chemical stimuli and would not react to electronic signals. Neither plants nor fungi are able to receive electronic signals. Even if there were higher organisms on some planet, it would be rather improbable that they would have developed the same sense organs that we have. All civilizations have only a short duration. I will try to emphasize the importance of this point by telling a little fable. Let us assume that there were really intelligent beings on another planet in our galaxy. A billion years ago their astronomers discovered Earth and reached the conclusion that this planet might have the proper conditions to produce intelligence. To test this, they sent signals to Earth for a billion years without ever getting an answer. Finally, in the year of our calendar they decided they would send signals only for another years. By the year , no answer had been received, so they concluded that surely there was no intelligent life on Earth. This shows that even if there were thousands of civilizations in the universe, the probability of a successful communication would be extremely slight because of the short duration of the "open window. The fact that there are a near infinite number of additional galaxies in the universe is irrelevant as far as SETI projects are concerned. An Improbability of Astronomic Dimensions What conclusions must we draw from these considerations? No less than six of the eight conditions to be met for SETI success are highly improbable. When one multiplies these six improbabilities with each other, one reaches an improbability of astronomic dimensions. Why are there nevertheless still proponents of SETI? When one looks at their qualifications, one finds that they are almost exclusively astronomers, physicists and engineers. They are simply unaware of the fact that the success of any SETI effort is not a matter of physical laws and engineering capabilities but essentially a matter of biological and sociological factors. These, quite obviously, have been entirely left out of the calculations of the possible success of any SETI project. Considered one of the leading biologists of this century, the year-old Mayr is the author of about papers and 20 books. He is known for his work in ornithology and systematics and, as a leader in evolutionary biology, he has written about the development of species, overpopulation, biodiversity, and, most recently, SETI.

Chapter 3 : The Search for Life in the Universe -- NASA Astrobiology Magazine | NASA

Carl Sagan, along with astronomer Frank Drake, began the search for extraterrestrial intelligence, which came to be known as SETI, in the s, and in the SETI Institute was formed.

Finding Life Beyond Earth Is there intelligence elsewhere in the universe? After all, the universe is so big. As the iconic scientist Carl Sagan put it, "there are billion galaxies, each of which contains something like billion stars. In addition to the staggering numbers, the history of science has shown that every time we think we are special in some way, we turn out to be wrong. The sun does not revolve around the Earth, the sun is not the only star, we are not the center of our galaxy, and our galaxy is not the center of the universe. There may even be multiple universes. Like so many important questions for which there are little data but different ways to examine the question, finding an answer can get complicated very quickly. At the time Seth Shostak was a graduate student doing radio astronomy at the Owens Valley Radio Observatory in California, and while there he got hooked on a new book, Intelligent Life in the Universe, by the astronomers I. Shklovskii and Carl Sagan. By tuning into the correct frequency, we could eventually hear from someone. The array links together a large number of small dishes rather than relying on the individual large antennas traditionally used to listen to the sky. The equation included a factor for everything that seemed relevant to the question. Thus Nâ€”the number of civilizations in our galaxy with which communication might be possibleâ€”would be equal to the average rate of star formation per year in our galaxy, times the fraction of those stars that have planets, times the average number of planets that can support life per star that has planets, times the fraction of the above that go on to actually develop life, times the fraction of those that evolve intelligence, times the percentage of those that invent interstellar communication capabilities, times the average length of time that such civilizations release detectable signals into space. Note that if any one of these factors is zero, then there are no ETs out there. Drake plugged in what he thought were reasonable values and came up with an estimate: But at the time, the values he could assign were at best educated guesses, and in some cases little more than speculation. Despite how little data existed, excitement about the possibility of finding ET grew during the s as solar system exploration expanded. In , the twin Voyager spacecraft 1 and 2 launched carrying gold-plated copper records inscribed with messages from Earth, including songs, images of our planet, and spoken greetings in 55 languages. The two spacecraft left the solar system in and are now travelling through interstellar space. The contents of the so-called "Golden Record" were meant to be a selection of meaningful information we could share with alien intelligences, should they ever encounter the Voyager spacecraft. Salutations included, in Armenian, "To all those who exist in the universe, greetings. In addition, the estimated value for another factorâ€”the number of planets that might be habitableâ€”keeps going up. Discoveries here on Earth of so-called extremophiles, organisms that can live in conditions previously thought to be inhospitable to life, coupled with discoveries in the solar system of environments not so dissimilar, has fueled optimism that we may find simple extraterrestrial life in our solar system in the not-too-distant future. But life survives in the driest spot of another desert, the Mojave, beneath the shelter of translucent white rocks. While these chemicals might not seem conducive to living things, life may be more flexible than we give it credit for: The waters of Mono Lake in California are extremely salty and alkaline, and they have high levels of arsenic. Yet bacteria thrive there. And it has excess heat up the wazoo, more heat than we know what to do with. Here on Earth, life took hold more than half a billion years after our planet formed, but because we only have one example of life arising, there is no way to know if the development of life will always take that length of time. It could take longer, which would reduce the number of planets where life has enough time to evolve, or it could happen more quickly, which would increase that number. But would it always take that amount of time, and was it even inevitable? Some scientists point out that human intelligence was contingent on numerous things going just right, such as an asteroid hitting the Earth 65 million years ago, simultaneously wiping out the dinosaurs and making our evolution possible. The late evolutionary biologist Stephen Jay Gould questioned whether, if you rewound the tape of life, a creature like us would evolve again. He found a kindred spirit in astronomer Donald Brownlee. I think the same thing," and they were off. In , they published a book called Rare Earth: While Ward agrees odds are that ET must exist somewhere, he concludes that the universe is so large that, for all intents and purposes, we are alone. To drive home the point, Ward and Brownlee came up with a new version of the Drake Equation, to which they added factors they believed had been overlooked, such as the fraction of planets with a large moon, the fraction of planetary systems with Jupiter-sized planets, and the fraction of planets with a critically low number of mass extinctions. They called it the Rare Earth Equation. Ward and Brownlee also assigned a very low number to how often intelligence would develop and to the length of time communicating intelligences would last. When you have too many people and no food, and civilization falls into chaos, how much civilization is retained? How long will an intelligent species survive? Such a so-called "Goldilocks" planet would have to be the right size, neither too close nor too far from the right kind of star, with liquid water and a low number of mass extinction events, to name just a few essential conditions. But it does mean that we can hear you, and then, suddenly, we define you as intelligent. The SETI Institute temporarily lost funding for its Allen Telescope Arrayâ€”the most advanced instrument for detecting electromagnetic signals from ETâ€”but private funding is bringing it back online. We can do something about it. We can actually mount an experiment that looks good on paper. How crazy would it be not to at least try? But it can never be disconfirmed. Says Carolyn Porco of the Cassini mission to Saturn, "If we ever discover that genesis has occurred independently twice in our solar system, that means that no matter where we find it, the spell has been broken. We could infer that life is not a bug but a feature of the universe in which we live, and that means that life has occurred a staggering number of times throughout the

Chapter 4 : Extraterrestrial life - Wikipedia

Heller and Pudritz propose that the Breakthrough Listen Initiative, part of the most comprehensive search for extraterrestrial life ever conducted, can maximize its chances of success by.

Click search or press enter Where Are They? Where there is water, there may be life. After more than 40 years of human exploration, culminating in the ongoing Mars Exploration Rover mission, scientists are planning still more missions to study the planet. The next decade might see a Mars Sample Return mission, which would use robotic systems to collect samples of Martian rocks, soils, and atmosphere and return them to Earth. We could then analyze the samples to see if they contain any traces of life, whether extinct or still active. Star clusters, as viewed through the Hubble Telescope: Although there are about billion stars in our galaxy, and billion galaxies in the observable universe, the human race seems to be alone. Such a discovery would be of tremendous scientific significance. What could be more fascinating than discovering life that had evolved entirely independently of life here on Earth? Many people would also find it heartening to learn that we are not entirely alone in this vast, cold cosmos. It would be good news if we find Mars to be sterile. Dead rocks and lifeless sands would lift my spirit. Conversely, if we discovered traces of some simple, extinct life-formâ€"some bacteria, some algaeâ€"it would be bad news. If we found fossils of something more advanced, perhaps something that looked like the remnants of a trilobite or even the skeleton of a small mammal, it would be very bad news. The more complex the life-form we found, the more depressing the news would be. I would find it interesting, certainlyâ€"but a bad omen for the future of the human race. How do I arrive at this conclusion? I begin by reflecting on a well-known fact. We have not received any visitors from space, nor have our radio telescopes detected any signals transmitted by any extraterrestrial civilization. As best we have been able to determine, the night sky is empty and silent. Here is another fact: Most of these are gigantic, since it is very difficult to detect smaller exoplanets using current methods. In most cases, the planets cannot be directly observed. Their existence is inferred from their gravitational influence on their parent suns, which wobble slightly when pulled toward large orbiting planets, or from slight fluctuations in luminosity when the planets partially eclipse their suns. We have every reason to believe that the observable universe contains vast numbers of solar systems, including many with planets that are Earth-like, at least in the sense of having masses and temperatures similar to those of our own orb. We also know that many of these solar systems are older than ours. The filter consists of one or more evolutionary transitions or steps that must be traversed at great odds in order for an Earth-like planet to produce a civilization capable of exploring distant solar systems. You start with billions and billions of potential germination points for life, and you end up with a sum total of zero extraterrestrial civilizations that we can observe. The Great Filter must therefore be sufficiently powerfulâ€"which is to say, passing the critical points must be sufficiently improbableâ€"that even with many billions of rolls of the dice, one ends up with nothing: At least, none that we can detect in our neck of the woods. Now, just where might this Great Filter be located? There are two possibilities: It might be behind us, somewhere in our distant past. Or it might be ahead of us, somewhere in the decades, centuries, or millennia to come. Let us ponder these possibilities in turn. If the filter is in our past, there must be some extremely improbable step in the sequence of events whereby an Earth-like planet gives rise to an intelligent species comparable in its technological sophistication to our contemporary human civilization. Some people seem to take the evolution of intelligent life on Earth for granted: But this view might well be completely mistaken. There is, at any rate, hardly any evidence to support it. Evolutionary biology, at the moment, does not enable us to calculate from first principles how probable or improbable the emergence of intelligent life on Earth was. Moreover, if we look back at our evolutionary history, we can identify a number of transitions any one of which could plausibly be the Great Filter. No instance of abiogenesis the spontaneous emergence of life from nonlife has ever been observed. The oldest confirmed microfossils date from approximately 3. Life might have arisen considerably earlier than that without leaving any traces: Nevertheless, several hundred million years elapsed between the formation of Earth and the appearance of the first known life-forms. The evidence is thus consistent with the hypothesis that the emergence of life required an extremely improbable set of coincidences, and that it took hundreds of millions of years of trial and error, of molecules and surface structures randomly interacting, before something capable of self-replication happened to appear by a stroke of astronomical luck. For aught we know, this first critical step could be a Great Filter. Conclusively determining the probability of any given evolutionary development is difficult, since we cannot rerun the history of life multiple times. What we can do, however, is attempt to identify evolutionary transitions that are at least good candidates for being a Great Filterâ€"transitions that are both extremely improbable and practically necessary for the emergence of intelligent technological civilization. One criterion for any likely candidate is that it should have occurred only once. Flight, sight, photosynthesis, and limbs have all evolved several times here on Earth and are thus ruled out. Another indication that an evolutionary step was very improbable is that it took a very long time to occur even after its prerequisites were in place. A long delay suggests that vastly many random recombinations occurred before one worked. Perhaps several improbable mutations had to occur all at once in order for an organism to leap from one local fitness peak to another: The evolution of Homo sapiens from our recent hominid ancestors, such as Homo erectus, happened rather quickly on the geological timescale, so these steps would be relatively weak candidates for a Great Filter. The original emergence of life appears to meet these two criteria. As far as we know, it might have occurred only once, and it might have taken hundreds of millions of years for it to happen even after the planet had cooled down enough for a wide range of organic molecules to be stable. Later evolutionary history offers additional possible Great Filters. For example, it took some 1. That is a long time, making this transition an excellent candidate. Others include the emergence of multicellular organisms and of sexual reproduction. If the Great Filter is indeed behind us, meaning that the rise of intelligent life on any one planet is extremely improbable, then it follows that we are most likely the only technologically advanced civilization in our galaxy, or even in the entire observable universe. The observable universe contains approximately stars. The universe might well extend infinitely far beyond the part that is observable by us, and it may contain infinitely many stars. If so, then it is virtually certain that an infinite number of intelligent extraterrestrial species exist, no matter how improbable their evolution on any given planet. However, cosmological theory implies that because the universe is expanding, any living creatures outside the observable universe are and will forever remain causally disconnected from us: The other possibility is that the Great Filter is still ahead of us. This would mean that some great improbability prevents almost all civilizations at our current stage of technological development from progressing to the point where they engage in large-scale space colonization. I will return to this scenario shortly, but first I shall say a few words about another theoretical possibility: I think that this is unlikely, because if extraterrestrials do exist in any numbers, at least one species would have already expanded throughout the galaxy, or beyond. Yet we have met no one. Various schemes have been proposed for how intelligent species might colonize space. A probe would land on a planet or a moon or asteroid , where it would mine raw materials to create multiple replicas of itself, perhaps using advanced forms of nanotechnology. In a scenario proposed by Frank Tipler in , replicas would then be launched in various directions, setting in motion a multiplying colonization wave. Our galaxy is about , light-years across. If a probe were capable of traveling at one-tenth the speed of light, every planet in the galaxy could thus be colonized within a couple of million years allowing some time for each probe that lands on a resource site to set up the necessary infrastructure and produce daughter probes. If travel speed were limited to 1 percent of light speed, colonization might take 20 million years instead. The exact numbers do not matter much, because the timescales are at any rate very short compared with the astronomical ones on which the evolution of intelligent life occurs. If building a von Neumann probe seems very difficultâ€"well, surely it is, but we are not talking about something we should begin work on today. Rather, we are considering what would be accomplished with some very advanced technology of the future. We might build von Neumann probes in centuries or millenniaâ€"intervals that are mere blips compared with the life span of a planet. Considering that space travel was science fiction a mere half-century ago, we should, I think, be extremely reluctant to proclaim something forever technologically infeasible unless it conflicts with some hard physical constraint. Our early space probes are already out there: Voyager 1, for example, is now at the edge of our solar system. Even if an advanced technological civilization could spread throughout the galaxy in a relatively short period of time and thereafter spread to neighboring galaxies , one might still wonder whether it would choose to do so. Perhaps it would prefer to stay at home and live in harmony with nature. However, a number of considerations make this explanation of the great silence less than plausible. First, we observe that life has here on Earth manifested a very strong tendency to spread wherever it can. It has populated every nook and cranny that can sustain it: This empirical finding is of course entirely consonant with what one would expect on the basis of elementary evolutionary theory. Second, if we consider our own species in particular, we find that it has spread to every part of the planet, and we have even established a presence in space, at vast expense, with the International Space Station. Third, if an advanced civilization has the technology to go into space relatively cheaply, it has an obvious reason to do so: These resources could be used to support a growing population and to construct giant temples or supercomputers or whatever structures a civilization values. It takes but one match to start a fire, only one expansionist civilization to begin colonizing the universe. For all these reasons, it seems unlikely that the galaxy is teeming with intelligent beings that voluntarily confine themselves to their home planets. Now, it is possible to concoct scenarios in which the universe is swarming with advanced civilizations every one of which chooses to keep itself well hidden from our view. The more disconcerting hypothesis is that the Great Filter consists in some destructive tendency common to virtually all sufficiently advanced technological civilizations. Throughout history, great civilizations on Earth have implodedâ€"the Roman Empire, the Mayan civilization that once flourished in Central America, and many others. However, the kind of societal collapse that merely delays the eventual emergence of a space-colonizing civilization by a few hundred or a few thousand years would not explain why no such civilization has visited us from another planet.

Chapter 5 : Consent Form | Popular Science

The search for extraterrestrial life is seen as one of pure curiosity. But, as in other areas of science, we should worry about the consequences of success.

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To the extent you select the secure connection method or your browser supports such functionality, all credit card account information that you supply is transmitted via secure encryption technology. We will provide notice if we become aware of any security breach that may affect any sensitive personal information pertaining to you that we have stored on our systems. Bonnier employees, agents, and contractors who have access to personally-identifying information are required to protect this information in a manner that is consistent with this Privacy Policy and may not use the information for any purpose other than to carry out the services they are performing for Bonnier. These individuals are bound by confidentiality obligations and may be subject to discipline, including termination and criminal prosecution, if they fail to meet these obligations. Bonnier only collects personal information that is relevant to the purposes for which it will be used. Though we do take appropriate steps to review and update the information that we store to ensure that it is accurate, complete, and current, we also depend on you to update or correct your personal information when necessary. You may correct or delete any or all of the personal information you have provided to us at any time. Many of our websites provide means to review and update the personal information that you have provided on that website. To inquire about personally identifiable information that Bonnier has collected about you, or about other ways to correct factual errors in that information, please send us an e-mail at privacy bonniercorp. Do not use this email address to send questions about your subscription. To protect your privacy and security, we will take reasonable steps to help verify your identity before granting access or making corrections. We will decline to process requests where we cannot verify the identity of the requester. We may also decline to process requests that are automated, repetitive, systematic, or impractical, or that might jeopardize the privacy of others. In some limited circumstances, such as to resolve disputes, troubleshoot problems, and enforce our policies, we may retain some of information that you have requested us to remove. Therefore, you should not expect that all of your personal information will be completely removed from our databases in response to your requests. We only use the information we collect for purposes consistent with this policy. If we propose to use your personal information for purposes beyond that explained in this policy, we will provide appropriate notice before doing so and we will provide you with the means to opt out of those uses. We will not use your sensitive personal information for any purposes other than those described in this Policy unless we have obtained your consent. Your privacy options If you prefer not to receive e-mail communications from other companies, you may choose to remove yourself from any e-mail lists that we provide to third parties for marketing purposes by sending us an e-mail at emailoptout bonniercorp. You will still receive information from Bonnier and its various brands, but we will not share your address information with anyone else. If you prefer not to receive postal communication from other companies, you may choose to remove yourself from any postal mailing lists that we provide to third parties for marketing purposes by sending us an e-mail at emailoptout bonniercorp. Box , Harlan, IA We only want to communicate with you if you want to hear from us. If you prefer not to be contacted at all, you may opt out of receiving any communications from us at any time by notifying us at emailoptout bonniercorp. You may also notify us by sending mail to the following address:

Chapter 6 : BBC - Future - Extraterrestrial life

Extraterrestrial Life Could Be Purple October 22, | Article Earth's early life might have been purple, suggesting the search for extraterrestrial life should scan for the color.

This hypothesis relies on the vast size and consistent physical laws of the observable universe. According to this argument, made by scientists such as Carl Sagan and Stephen Hawking , [6] as well as well-regarded thinkers such as Winston Churchill , [7] [8] it would be improbable for life not to exist somewhere other than Earth. Alternatively, life may have formed less frequently, then spreadâ€”by meteoroids , for exampleâ€”between habitable planets in a process called panspermia. Numerous discoveries in such zones since have generated numerical estimates of Earth-like planets â€"in terms of compositionâ€"of many billions. One of the study authors, Sam Levin, notes "Like humans, we predict that they are made-up of a hierarchy of entities, which all cooperate to produce an alien. At each level of the organism there will be mechanisms in place to eliminate conflict, maintain cooperation, and keep the organism functioning. We can even offer some examples of what these mechanisms will be. It has been suggested that this capacity arises with the number of potential niches a planet contains, and that the complexity of life itself is reflected in the information density of planetary environments, which in turn can be computed from its niches. Sufficient quantities of carbon and other elements, along with water, might enable the formation of living organisms on terrestrial planets with a chemical make-up and temperature range similar to that of Earth. It is also conceivable that there are forms of life whose solvent is a liquid hydrocarbon , such as methane , ethane or propane. These six elements form the basic building blocks of virtually all life on Earth, whereas most of the remaining elements are found only in trace amounts. The carbon atom has the unique ability to make four strong chemical bonds with other atoms, including other carbon atoms. These covalent bonds have a direction in space, so that carbon atoms can form the skeletons of complex 3-dimensional structures with definite architectures such as nucleic acids and proteins. Carbon forms more compounds than all other elements combined. The great versatility of the carbon atom makes it the element most likely to provide the basesâ€"even exotic onesâ€"for the chemical composition of life on other planets. Planetary habitability , Habitability of natural satellites , and Exobiology Some bodies in the Solar System have the potential for an environment in which extraterrestrial life can exist, particularly those with possible subsurface oceans. Important insights on the limits of microbial life can be gleaned from studies of microbes on modern Earth, as well as their ubiquity and ancestral characteristics. If extraterrestrial life was found on another body in the Solar System , it could have originated from Earth just as life on Earth could have been seeded from elsewhere exogenesis. The Nobel prize winner Francis Crick , along with Leslie Orgel proposed that seeds of life may have been purposely spread by an advanced extraterrestrial civilization, [46] but considering an early " RNA world " Crick noted later that life may have originated on Earth. However, between an altitude of 50 and 65 kilometers, the pressure and temperature are Earth-like, and it has been speculated that thermoacidophilic extremophile microorganisms might exist in the acidic upper layers of the Venusian atmosphere. Life on Mars Life on Mars has been long speculated. Liquid water is widely thought to have existed on Mars in the past, and now can occasionally be found as low-volume liquid brines in shallow Martian soil. Scientists have indications that heated subsurface oceans of liquid water may exist deep under the crusts of the three outer Galilean moons â€"Europa, [37] [38] [75] Ganymede , [76] [77] [78] [79] [80] and Callisto. Life on Europa Internal structure of Europa. The blue is a subsurface ocean. Such subsurface oceans could possibly harbor life. Enceladus Enceladus , a moon of Saturn, has some of the conditions for life, including geothermal activity and water vapor, as well as possible under-ice oceans heated by tidal effects. The temperature and density of the plumes indicate a warmer, watery source beneath the surface. Life on Titan Titan , the largest moon of Saturn , is the only known moon in the Solar System with a significant atmosphere. Data from the Cassiniâ€"Huygens mission refuted the hypothesis of a global hydrocarbon ocean, but later demonstrated the existence of liquid hydrocarbon lakes in the polar regionsâ€"the first stable bodies of surface liquid discovered outside Earth. Fred Hoyle and Chandra Wickramasinghe have proposed that microbial life might exist on comets and asteroids. This is in contrast with the oceans that may be inside larger icy satellites like Ganymede, Callisto, or Titan, where layers of high-pressure phases of ice are thought to underlie the liquid water layer. Direct search Lifeforms produce a variety of biosignatures that may be detectable by telescopes. It is designed to assess the past and present habitability on Mars using a variety of scientific instruments. The rover landed on Mars at Gale Crater in August However, significant advances in the ability to find and resolve light from smaller rocky worlds near their star are necessary before such spectroscopic methods can be used to analyze extrasolar planets. To that effect, the Carl Sagan Institute was founded in and is dedicated to the atmospheric characterization of exoplanets in circumstellar habitable zones. The molecule was found around the protostellar binary IRAS , which is located light years from Earth. This finding suggests that complex organic molecules may form in stellar systems prior to the formation of planets, eventually arriving on young planets early in their formation. The length of time required for a signal to travel across the vastness of space means that any signal detected would come from the distant past.

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Chapter 7 : Where Are They? - MIT Technology Review

This essay first appeared in in NASA's Astrobiology magazine.

July 20, The first of the two initiatives announced today, Breakthrough Listen, will be the most powerful search ever taken for signs of intelligent life beyond Earth. The project will survey the 1 million stars in the Milky Way closest to Earth, as well as the closest galaxies. Or do our lights wander a lifeless cosmos, unseen beacons announcing that, here on one rock, the universe discovered its existence? Either way, there is no better question. The Breakthrough initiatives are making that commitment. Breakthrough Listen and Breakthrough Message are funded by Silicon Valley technology investor Yuri Milner, who was trained as a physicist. Kennedy announced his dream of landing a man on the moon by the end of this decade," Milner said at the news conference. That same year, , Yuri Gagarin became the first human in space. It was an important year for humanity; we stepped out into the solar system. And it was an important year for me; I was born. Later, I was told by my mother, who is right here in this room, that she wanted me to be inspired by what he did. No - Aliens are just part of science fiction. From a "nearby" star 25 trillion miles 40 trillion kilometers away, it could detect a watt laser emitting the same amount of energy as a normal household light bulb,the statement added. The initiative will collect vast amounts of data â€" 10GB per second â€" the largest amount of scientific data ever made available to the public. The plan is for the Breakthrough Listen team to develop powerful open-source software to search through this flood of data. Scientists and members of the public can develop their own applications to analyze this data as well. Crowdsourcing SETI Breakthrough Listen will also take advantage of crowdsourcing by joining and supporting SETI home, the distributed computing project in which 9 million volunteers around the world donate spare computing power to search for signs of extraterrestrial life. If Breakthrough Listen does not discover extraterrestrial intelligence a decade from now, "as long as we collectively believe this is an endeavor worth funding, we should just keep funding," Milner said. It remains unknown, however, what form any extraterrestrial intelligence might take , if it exists at all. A civilization reading one of our messages could be billions of years ahead of us. If so, they will be vastly more powerful, and may not see us as any more valuable than we see bacteria.

Chapter 8 : Home | SETI Institute

The search for extraterrestrial life received a major boost Monday with the launch of an ambitious $ million program, backed by famed physicist Stephen Hawking and tech billionaire Yuri Milner.

Early work[edit] There have been many earlier searches for extraterrestrial intelligence within the Solar System. In , Nikola Tesla suggested that an extreme version of his wireless electrical transmission system could be used to contact beings on Mars. At the United States Naval Observatory , a radio receiver was lifted 3 kilometres 1. Friedman chief cryptographer of the United States Army , assigned to translate any potential Martian messages. A kilohertz band around the marker frequency was scanned, using a single-channel receiver with a bandwidth of hertz. He found nothing of interest. Soviet scientists took a strong interest in SETI during the s and performed a number of searches with omnidirectional antennas in the hope of picking up powerful radio signals. Soviet astronomer Iosif Shklovsky wrote the pioneering book in the field, Universe, Life, Intelligence , which was expanded upon by American astronomer Carl Sagan as the best-selling book Intelligent Life in the Universe Kraus described an idea to scan the cosmos for natural radio signals using a flat-plane radio telescope equipped with a parabolic reflector. Within two years, his concept was approved for construction by Ohio State University. Oliver of Hewlett-Packard Corporation, and others. The resulting report proposed the construction of an Earth-based radio telescope array with 1, dishes known as " Project Cyclops ". Cyclops was not built, but the report [17] formed the basis of much SETI work that followed. He quickly circled the indication on a printout and scribbled the exclamation "Wow! Traditional desktop spectrum analyzers were of little use for this job, as they sampled frequencies using banks of analog filters and so were restricted in the number of channels they could acquire. However, modern integrated-circuit digital signal processing DSP technology could be used to build autocorrelation receivers to check far more channels. This work led in to a portable spectrum analyzer named "Suitcase SETI" that had a capacity of , narrow band channels. This project was named "Sentinel" and continued into The META spectrum analyzer had a capacity of 8. An important feature of META was its use of frequency Doppler shift to distinguish between signals of terrestrial and extraterrestrial origin. The project was led by Horowitz with the help of the Planetary Society, and was partly funded by movie maker Steven Spielberg. This allowed BETA to receive million simultaneous channels with a resolution of 0. It scanned through the microwave spectrum from 1. An important capability of the BETA search was rapid and automatic re-observation of candidate signals, achieved by observing the sky with two adjacent beams, one slightly to the east and the other slightly to the west. A third receiver observed the horizon to veto signals of obvious terrestrial origin. The diagonal lines show transmitters of different effective powers. The x-axis is the sensitivity of the search. The y-axis on the right is the range in light-years , and on the left is the number of Sun-like stars within this range. The vertical line labeled TS is the typical sensitivity achieved by a targeted search such as Phoenix. MOP was planned as a long-term effort to conduct a general survey of the sky and also carry out targeted searches of specific nearby stars. The signals were to be analyzed by spectrum analyzers, each with a capacity of 15 million channels. These spectrum analyzers could be grouped together to obtain greater capacity. Those used in the targeted search had a bandwidth of 1 hertz per channel, while those used in the sky survey had a bandwidth of 30 hertz per channel. MOP drew the attention of the United States Congress , where the program was ridiculed [22] and canceled one year after its start. Project Phoenix , under the direction of Jill Tarter , is a continuation of the targeted search program from MOP and studies roughly 1, nearby Sun -like stars. Furthermore, human endeavors emit considerable electromagnetic radiation as a byproduct of communications such as television and radio. These signals would be easy to recognize as artificial due to their repetitive nature and narrow bandwidths. If this is typical, one way of discovering an extraterrestrial civilization might be to detect artificial radio emissions from a location outside the Solar System. Its sensitivity would be equivalent to a single large dish more than meters in diameter if completed. Presently, the array under construction has 42 dishes at the Hat Creek Radio

Observatory in rural northern California. These dishes are the largest producible with commercially available satellite television dish technology. The first portion of the array ATA became operational in October with 42 antennas. Completion of the full element array will depend on funding and the technical results from ATA ATA ATA is designed to allow multiple observers simultaneous access to the interferometer output at the same time. Multibeaming provides an effective filter for identifying false positives in SETI, since a very distant transmitter must appear at only one point on the sky. From , ATA has identified hundreds of millions of technological signals. Regular operation of the ATA was resumed on December 5, As of July, the first of these receivers was installed and proven. Full installation on all 42 antennas is expected in June, Rather than having its own observation program, SERENDIP analyzes deep space radio telescope data that it obtains while other astronomers are using the telescopes. The program has found around suspicious signals, but there is not enough data to prove that they belong to extraterrestrial intelligence. Announced in July , the project is observing for thousands of hours every year on two major radio telescopes, the Green Bank Observatory in West Virginia and the Parkes Observatory in Australia. This is compared to the Arecibo meter telescope detection distance of 18 light-years. The project is run by director David P. Anderson and chief scientist Dan Werthimer. The SETI home program itself runs signal analysis on a "work unit" of data recorded from the central 2. After computation on the work unit is complete, the results are then automatically reported back to SETI home servers at University of California, Berkeley. By June 28, , the SETI home project had over , active participants volunteering a total of over , computers. The SETI Net station consists of off-the-shelf, consumer-grade electronics to minimize cost and to allow this design to be replicated as simply as possible. The antenna can be pointed and locked to one sky location, enabling the system to integrate on it for long periods. All search data are collected and made available on the Internet archive. SETI Net started operation in the early s as a way to learn about the science of the search, and has developed several software packages for the amateur SETI community. It has provided an astronomical clock, a file manager to keep track of SETI data files, a spectrum analyzer optimized for amateur SETI, remote control of the station from the Internet, and other packages. This grass-roots alliance of amateur and professional radio astronomers is headed by executive director emeritus H. Others are digital signal processing experts and computer enthusiasts. There are currently Project Argus radio telescopes operating in 27 countries. The name "Argus" derives from the mythical Greek guard-beast who had eyes, and could see in all directions at once. Clarke, " Imperial Earth "; Carl Sagan, " Contact " , was the name initially used for the NASA study ultimately known as "Cyclops," and is the name given to an omnidirectional radio telescope design being developed at the Ohio State University. Optical experiments[edit] While most SETI sky searches have studied the radio spectrum, some SETI researchers have considered the possibility that alien civilizations might be using powerful lasers for interstellar communications at optical wavelengths. The idea was first suggested by R. However, the Cyclops study discounted the possibility of optical SETI, reasoning that construction of a laser system that could outshine the bright central star of a remote star system would be too difficult. In , Townes published a detailed study of the idea in the United States journal Proceedings of the National Academy of Sciences , [63] which was met with widespread agreement by the SETI community. However, emitting light in narrow pulses results in a broad spectrum of emission; the spread in frequency becomes higher as the pulse width becomes narrower, making it easier to detect an emission. The other problem is that while radio transmissions can be broadcast in all directions, lasers are highly directional. Interstellar gas and dust is almost transparent to near infrared, so these signals can be seen from greater distances, but the extraterrestrial laser signals would need to be transmitted in the direction of Earth in order to be detected. The Cyclops study proved incorrect in suggesting a laser beam would be inherently hard to see. Such a system could be made to automatically steer itself through a target list, sending a pulse to each target at a constant rate. This would allow targeting of all Sun-like stars within a distance of light-years. The studies have also described an automatic laser pulse detector system with a low-cost, two-meter mirror made of carbon composite materials, focusing on an array of light detectors. This automatic detector system could perform sky surveys to detect laser flashes from civilizations attempting contact. Several optical SETI experiments are now in progress. This telescope is currently being used for a more conventional star survey, and the optical SETI survey is " piggybacking " on that effort. Between October and November , the survey inspected about 2, stars. Nothing that resembled an intentional laser signal was detected, but efforts continue. The Harvard and Princeton telescopes will be "ganged" to track the same targets at the same time, with the intent being to detect the same signal in both locations as a means of reducing errors from detector noise. The Harvard-Smithsonian SETI group led by Professor Paul Horowitz built a dedicated all-sky optical survey system along the lines of that described above, featuring a 1. The optical SETI program at Breakthrough Listen is being directed by Geoffrey Marcy , an extrasolar planet hunter, and it involves examination of records of spectra taken during extrasolar planet hunts for a continuous, rather than pulsed, laser signal. This survey uses the Automated Planet Finder 2. This survey uses a centimeter inch automated telescope at Leuschner Observatory and an older laser detector built by Werthimer. In May , astronomers reported studies related to laser light emissions from stars, as a way of detecting technology-related signals from an alien civilization. The reported studies included KIC , an oddly dimming star in which its unusual starlight fluctuations may be the result of interference by an artificial megastructure, such as a Dyson swarm , made by such a civilization. No evidence was found for technology-related signals from KIC in the studies. These high-energy bursts are observed about once per day and originate throughout the observable universe. In addition, the wide burst bandwidths pose a serious analysis challenge for modern digital signal processing systems. Still, the continued mysteries surrounding gamma-ray bursts have encouraged hypotheses invoking extraterrestrials. Starting in , Robert Freitas advanced arguments [71] [72] [73] for the proposition that physical space-probes are a superior mode of interstellar communication to radio signals. See Voyager Golden Record. In recognition that any sufficiently advanced interstellar probe in the vicinity of Earth could easily monitor the terrestrial Internet , Invitation to ETI was established by Prof. Allen Tough in , as a Web-based SETI experiment inviting such spacefaring probes to establish contact with humanity.

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Chapter 9 : SETI Debate : Critique of SETI

Alien Seas Icefin is meant to search for alien lifeâ€”a "bug hunt," as some scientists cheerfully call it. It is bound for the icy waters of Jupiter's moon, Europa, possibly as soon as

In July the Mariner IV probe sent back data showing that Mars did not have vegetation, much less canals crisscrossing the planet as envisioned by earlier generations of astronomers. Last month two convicted murders escaped from a New York prison. They had spent months carefully planning and executing their escape , which involved cutting and digging their way through walls, pipes and concrete. Remarkably, however, the pair gave little thought to what they would do if they actually succeeded in their plans. The consequence of the lack of planning was a short effort to flee from authorities followed by the death of one prisoner and re-capture of the other by authorities. The search for extra-terrestrial life shares some similarities. We are investing considerable attention and resources into the search, but little into thinking about the consequences of success. As Carl Sagan imagined, it is as if we expect to fail, which would be a relief. Assessing technologies and their implications for society is clearly important, but it seems that we have a bit of a blind spot when it comes to the possibility of success of projects like Breakthrough Listen. So, what should we be doing instead? Fortunately, we have developed various institutions and mechanisms for discussions among experts and the public on topics of science and technology. Yet, I find precious little evidence that these bodies, or their US or British counterparts, have devoted much attention to the social, political and cultural implications of the discovery of extraterrestrial life. As with the scientific literature more generally, when attention is focused on this topic it emphasizes the challenges of detection , but not its consequences. The United Nations briefly took up the issue of extraterrestrial life in , but has let the issue lapse since then. The conversation is only silly if we assume that efforts to detect alien life will never succeed. Good decision making typically involves exploring the consequences of uncertainties and areas of ignorance. Perhaps it is no surprise that the best treatments of the consequences of the discovery of alien life come from popular literature and Hollywood. But they are not a complete substitute for a broader societal discussion. The 21st century is one in which science and technology are forcing a lot of important conversations among experts and the public across civil society. Energy systems, agricultural technologies, diseases, extreme events and disasters, terrorism, artificial intelligence, gene editing, synthetic biology â€¦ the list seems to have no end. Should we also be talking about the societal consequences of discovering extraterrestrial life? My answer is the same one I apply to other areas of investigation and invention. So long as we are searching, we should be discussing the consequences of success of that search. If we discover alien life we may not end up dead or captured, like the New York prison escapees, but we will better prepared for the possibility of success if we consider success possible. Given the profound implications of a discovery of life beyond Earth, it is irresponsible to embark upon a search without a parallel effort to help society prepare for success in that effort, or even the implications of continued failures.