Posted on 17 Apr 2023 — The copyright holder is the author/funder. All rights reserved. No reuse without permission. — https://doi.org/10.15200/winn.151117.75055 — This a preprint and has not been peer reviewed. Data may be preliminary.

Science AMA Series: We are Astrobiologists from different institutions around the world. We research the origin of life on Earth and the search for life elsewhere in the Universe. Fermi paradox, exoplanets, evolution of life, etc. Ask Us Anything!

Astrobiologists [1] and r/Science AMAs[1]

[1]Affiliation not available

April 17, 2023

Abstract

EDIT: .... and that's a wrap! Thank you all for your great questions. We had so much fun answering them. We look forward to interacting with you again in the future! Hi Reddit! We are Martin Van Kranendonk, Tara Djokic, Dave Deamer, Bruce Damer, Jonti Horner and Graham Lau from several institutions around the world. We are Astrobiologists and our research concerns the origin and evolution of life on Earth and the search for life elsewhere in the Universe. Martin and Tara published a paper in Nature in May this year which offers the oldest evidence of life on land found in a hot spring environment: https://www.nature.com/articles/ncomms15263. Their findings pushed back the earliest known evidence of life on land by a staggering 580 million years and has huge implications for the search for life on Mars. Watch this short video about their work: https://youtu.be/UdMKO2l-DzA Martin, Tara and Dave also wrote an article for Scientific American on the story behind their stunning findings. Their research represents an important piece of evidence in the Terrestrial Origin of Life Hypothesis conceived by Bruce, and supported by many lab experiments conducted by Bruce and Dave. Jonti's research includes the search for planets orbiting other stars (exoplanets), the formation and evolution of our Solar system, and the nature of habitability. Graham's research focuses on characterising the geochemistry of rare mineral forms in extreme environments and he is interested in how biology on Earth relates to the search for extraterrestrial life on worlds such as Mars and Europa. So far we can be certain that life has emerged once in the Universe: on Earth. NASA and other space agencies are working on designing probes and rovers that can be sent to other planets and planetary objects in the solar system to look for signs of life. The discovery of water on Mars in 2015 is a watershed moment for the Astrobiology community and we are anticipating many such important discoveries in the near future. It is an exciting time to be an Astrobiologist and we look forward to your questions! We will be back at 3pm ET to answer your questions. Ask us anything! Prof. Martin Van Kranendonk [MVK] website, Professor of Geology at the University of New South Wales, Australia, and the Director of the Australian Centre for Astrobiology Tara Djokic [TD] website, PhD candidate at the University of New South Wales, Australia Prof. Dave Deamer [DD] website, biologist and Research Professor of Biomolecular Engineering at the University of California, Santa Cruz, USA; author of 'First Life: Discovering the Connections between Stars, Cells, and How Life Began' Dr Bruce Damer [BD] website, associate researcher in the Department of Biomolecular Engineering at the University of California at Santa Cruz, USA Associate Prof. Jonti Horner [JH] website, astronomer and astrobiologist in the Computational Engineering and Science Research Centre at the University of Southern Queensland, Australia Dr Graham Lau [GL] website, astrobiologist and science communicator at Blue Marble Space

the WINNOWER

REDDIT

Science AMA Series: We are Astrobiologists from different institutions around the world. We research the origin of life on Earth and the search for life elsewhere in the Universe. Fermi paradox, exoplanets, evolution of life, etc. Ask Us Anything!

ASTROBIOLOGISTS R/SCIENCE

EDIT: .... and that's a wrap! Thank you all for your great questions. We had so much fun answering them. We look forward to interacting with you again in the future!

Hi Reddit!

We are Martin Van Kranendonk, Tara Djokic, Dave Deamer, Bruce Damer, Jonti Horner and Graham Lau from several institutions around the world. We are Astrobiologists and our research concerns the origin and evolution of life on Earth and the search for life elsewhere in the Universe.

Martin and Tara published a paper in Nature in May this year which offers the oldest evidence of life on land found in a hot spring environment: https://www.nature.com/articles/ncomms15263. Their findings pushed back the earliest known evidence of life on land by a staggering 580 million years and has huge implications for the search for life on Mars. Watch this short video about their work: https://youtu.be/UdMKO2l-DzA

Martin, Tara and Dave also wrote an article for Scientific American on the story behind their stunning findings. Their research represents an important piece of evidence in the Terrestrial Origin of Life Hypothesis conceived by Bruce, and supported by many lab experiments conducted by Bruce and Dave.

Jonti's research includes the search for planets orbiting other stars (exoplanets), the formation and evolution of our Solar system, and the nature of habitability. Graham's research focuses on characterising the geochemistry of rare mineral forms in extreme environments and he is interested in how biology on Earth relates to the search for extraterrestrial life on worlds such as Mars and Europa.

So far we can be certain that life has emerged once in the Universe: on Earth. NASA and other space agencies are working on designing probes and rovers that can be sent to other planets and planetary objects in the solar system to look for signs of life. The discovery of water on Mars in 2015 is a watershed moment for the Astrobiology community and we are anticipating many such important discoveries in the near future. It is an exciting time to be an Astrobiologist and we look forward to your questions!

We will be back at 3pm ET to answer your questions. Ask us anything!

Prof. Martin Van Kranendonk [MVK] website, Professor of Geology at the University of New South Wales, Australia, and the Director of the Australian Centre for Astrobiology

Tara Djokic [TD] website, PhD candidate at the University of New South Wales, Australia

Prof. Dave Deamer [DD] website, biologist and Research Professor of Biomolecular Engineering at the University of California, Santa Cruz, USA; author of 'First Life: Discovering the Connections between Stars, Cells, and How Life Began'

Dr Bruce Damer [BD] website, associate researcher in the Department of Biomolecular Engineering at the University of California at Santa Cruz, USA

Associate Prof. Jonti Horner [JH] website, astronomer and astrobiologist in the Computational Engineering and Science Research Centre at the University of Southern Queensland, Australia

Dr Graham Lau [GL] website, astrobiologist and science communicator at Blue Marble Space

READ REVIEWS

WRITE A REVIEW

CORRESPONDENCE:

DATE RECEIVED:
November 21, 2017

DOI:
10.15200/winn.151117.75055

ARCHIVED:
November 20, 2017

CITATION:
Astrobiologists , r/Science , Science AMA Series: We are Astrobiologists from different institutions around the world. We research the origin of life on Earth and the search for life elsewhere in the Universe. Fermi paradox, exoplanets, evolution of life, etc. Ask Us Anything!, *The Winnower* 4:e151117.75055 , 2017 , DOI: 10.15200/winn.151117.75055

© et al. This article is distributed under the terms of the Creative Commons Attribution 4.0 International License, which permits unrestricted use, distribution, and redistribution in any medium, provided that the original author and source are credited.

What is the most recent and most exciting discovery in the field of astrobiology?

CIA_Bane

DD That's a matter of opinion, of course, so here's two that attracted my attention. The evidence for liquid oceans on Enceladus and perhaps on Europa is pretty amazing, and so is the evidence that the microbial communities fossilized as ancient stromatolites in Western Australia lived in fresh water conditions.

What is the most recent and most exciting discovery in the field of astrobiology?

CIA_Bane

[JH] I'd agree with [DD] here :) I think the discovery of the geysers on Enceladus was probably my favourite astronomical discovery of the first decade of the 21st century. The other contender, I think, is the discovery that planets are ubiquitous - that pretty much every star has planets. The Kepler spacecraft has totally revolutionised our understanding of our place in the universe. That planets are everywhere is really exciting, to me, as it suggests that there will be myriad places where life could get going and thrive.

I also love the recent discovery of the first interstellar object seen passing through the Solar system. That's something we've long awaited - but to finally have confirmation that other planetary systems are flinging their leftovers out to space is really exciting. That discovery is really the prelude to some great future-science - with the next generation of survey telescopes (such as the Large Synoptic Survey Telescope, LSST), we should start finding more of these interstellar vagabonds. And if we find them with enough advance notice, we'll be able to learn a huge amount from them. With more time to focus our telescopes on them, we'll be able to study their physical properties (size, shape etc.), as well as their chemical makeup - and get hints as to what the composition of planets around other stars would be. The reasoning here is that the debris in a planetary system (the asteroids and comets) is made from the same stuff as the planets - and so is representative. So these interstellar vagabonds give us a close-up view of what the composition of planets in their original planetary system would be made from!

How close have scientists come to synthesizing life in the lab?

kaised

Much closer than 50 years ago, but still not close enough. Jack Szostak and his students at Harvard have been able to encapsulate nucleic acids in lipid membranes to make what we call protocells. The nucleic acids can be “fed” by nutrients added to the medium, and they grow by adding the nutrients, which are chemically activated nucleotides, to their chains in a template-dependent manner. Phil Holliger and his students at University College London have evolved a ribozyme that catalyzes polymerization reactions which synthesize RNA. Jerry Joyce and his students at the Salk Institute have shown how pairs of ribozymes can evolve in a test tube. Are these systems alive? Nope. Each manifests a property of life, such as polymerization, but none of them exhibit all of the properties in an integrated, cellular system – metabolism, replication, division into daughter cells and so on. We still have a ways to go.

What is your take on the Panspermia (I hope I spelt that correctly) theory?

Secondly, slightly more philosophical:

Do you think we are limiting ourselves when searching for extraterrestrial life? It seems to me as an outsider to the field, that we are looking for water, oxygen, appropriate sunlight etc as those factors are beneficial to life on our planet. Can we fully rule out that life originating under different circumstances could have drastically different requirements?

Lavidius

[JH] As an astronomer, I find Panspermia a fascinating idea. I can't speak to the biological side of things (the viability of bacteria when they get where they're going) - but all the evidence is that the transport of bacteria through impacts is definitely feasible. I used to work at the Open University, in the UK, many moons ago. People there were doing amazing experiments firing frozen bacteria at targets using, essentially, giant BB guns. This was to see if bacteria could survive the shocks that would be experienced in an impact large enough to eject intact rocks to space. The answer: they could. People have also done experiments to see whether bacteria could survive the trip to another world, and again, it seems likely they could.

As [BD] says, though, there's still a long way to go before this is feasible - after all, the bacteria would then have to land somewhere suitable, to let them get a foothold. I actually wonder whether the big test of Panspermia will come if we ever find life on Mars. My thinking here is that that life will have one of two origins:

1) A shared origin with life on Earth, thanks to panspermia (i.e. 'We are Martians', or 'Martians are Earthlings').

2) A separate, distinct origin (i.e. 'Martians are Martians, and Earthlings are Earthlings').

Would we be able to test to see which of these two cases is right? I don't know - maybe [BD] could comment? But either way, we'd learn something amazing about the nature of life in the universe. If [1] were true, then we'd know that life could be transported from world to world (and potentially from one planetary system to another), and so once life gets started somewhere, it should 'seed the cosmos', eventually... If [2] is true, then we'd know that life got started on two planets, side by side, which would likely have had somewhat different conditions on them. That tells us something about the ease with which life gets started!

Of course, there is option 3) - there is no other life in the Solar system. That would be sad, in my opinion, but will also be really hard to prove - after all, absence of evidence is not evidence of absence!

As for the second question - as an astronomer, I view this as being us trying to focus our efforts on where I chances of finding life are the greatest. We only know of a single place in the universe where life exists - the Earth. That means the one set of conditions we know for sure can support life are those we get here. That doesn't mean you can't life in other conditions - but it does mean we know one recipe that works.

That actually brings me to a big bugbear of mine about how we communicate about 'habitability'. When we talk about planets being 'in the habitable zone' around a star, what we *actually* mean is that, if you plonked the Earth, as it is today, onto the same orbit as the newly discovered planet, it would still be able to have liquid water on its surface. There's an implicit assumption there that people never make explicit - the assumption the planet is like Earth.

This gets a bit silly when people talk about a two Earth-mass planet being in the habitable zone - or a Mars-mass planet, for that matter. We think of the HZ in terms of the Solar system. Venus, too close to the Sun, is too hot. Mars, too far away, is too cold.

But what would happen if you magically swapped Venus and Mars over? Mars has a far thinner atmosphere, and less effective greenhouse than Venus. So if Venus were in Mars' orbit, it would probably be far closer to being habitable than Mars is. Similarly, put Mars on Venus' orbit, and it might still be habitable today (if it managed to hold on to what atmosphere it has!).

The other great hidden assumption that comes up when talking about 'potentially habitable exoplanets' is also based on this implicit 'Earth-like' bias. This is what I'd describe as a planet being 'detectably habitable'. In the Solar system, we have several icy moons that have oceans buried beneath their surfaces (such as Europa and Enceladus). These have regularly been put forward as locations in the Solar system where life could exist or thrive (though [MVK] has some great arguments to why that might not be the case!). However, whilst they might be 'habitable', they aren't 'detectably habitable'. If we found such icy worlds orbiting other stars, we'd have no way to peer through the ice to see what's beneath.

So I guess we are limiting ourselves, at least at first, by searching for a truly 'Earth-like' set of conditions. But it isn't due to a lack of imagination - but rather, is simply the result of our trying to maximise our chances of a positive result, given the technological challenges involved!

I remember the Star Trek episode "The Devil In The Dark" where there was silicone-based life. Do you think this is a possibility even here on Earth?

pkayemommy

[JH] I actually think if we ever find intelligent life beyond the Solar system, it could well be silicon-based life, rather than carbon-based life. I should caution I'm not a biologist (I'm your friendly Astronomer for the day!), and that I'm not talking about silicon-based life that evolved! I'm thinking, instead, of a second-generation of life - an extension of the robot envoys we're already scattering to the depths of space.

As years go by, our spacecraft are becoming ever more advanced and self-sufficient. The more distant their destination from Earth, the more autonomy we need to build into them. A good example of this is the Mars rovers - which have the ability to spot obstacles in their planned path, allowing them to stop and ask for help, rather than carrying on to catastrophe!

As time goes by, that technological advance is going to continue. When we get to the point of being able to send spacecraft to explore other planetary systems, they will need to be highly autonomous. It is one thing waiting an hour for an answer on 'what should I do?', and quite another to wait four years! So I suspect in the coming decades, scientists will make increasing use of artificial intelligence to make spacecraft better at doing their jobs unsupervised.

I don't know whether we, as a carbon-based species, will ever leave the Solar system - but we have already sent a number of spacecraft onto one-way voyages into the dark (such as New Horizons, and Voyager 1 and 2). If there is (or ever was) another technological civilisation out there, then I'd guess they would start their exploration of the galaxy with similar robot explorers - they're cheaper, and it is safer that way!

How advanced could such robots get? Would we ever count them as 'alive'? I don't know - but it certainly seems possible that the first signs of intelligent life we find out there could be silicon-based, rather than carbon-based - a second generation of life created by carbon-based masters!

Congratulations on your work!

Do you think that science-fiction, by popularizing scientific themes as space exploration, colonization, etc. to a wider non-scientific audience, plays an important role on the advancement of science? Did it have any influence on your decision to become astrobiologists and later on some of your research projects?

risosrisos

It sure did for me. The first book I can remember reading as a 10 year old growing up in Santa Monica was Rocket Ship Galileo, by Robert Heinlein. It was about a couple of teen-age boys and their uncle who constructed a rocket that took them to the moon! The book made a tremendous impression on me and now, much later, I still enjoy reading science fiction.

Congratulations on your work!

Do you think that science-fiction, by popularizing scientific themes as space exploration, colonization, etc. to a wider non-scientific audience, plays an important role on the advancement of science? Did it have any influence on your decision to become astrobiologists and later on some of your research projects?

risosrisos

[JH] I think science-fiction is a fantastic tool for getting people into science, and inspiring them to think outside the box :) I actually first became interested in astronomy thanks to a non-fiction astronomy program, called 'The Sky at Night' - but I know lots of my colleagues who were hooked as a result of watching 'Star Trek' as kids.

Sci-fi can also be a great teaching tool, to help people understand scientific theories. Whilst some of the ideas in it have fallen by the wayside, 'Tau Zero', by Poul Anderson, is an example that always sticks in my mind - a really interesting study of time dilation and relativity. As is 'The Forever War', by Joe Haldeman. There's some great sci-fi out there that takes the current scientific theories of the time and asks 'what if?' - and that's a great way to get people interested in the science, as well as telling a great story!

What is the most probable scenario of end of life on Earth?

MargaritaShir

[JH] That's a really hard question to ask! I don't think humanity is the answer - I'll say that up front. I don't think there's anything we could do (yet) that would sterilise the planet. Life is really durable, but also is buried deep - so I think to sterilise the Earth, you'd have to sterilise down to several kilometers depth. I was at a talk recently by [MVK] where he mentioned life has been found at least four kilometers under our feet - and life down there is going to be fairly well protected against events on the surface.

Moving further forward, though, life on Earth is doomed. That's down to the future evolution of the Sun, as it ages.

The Sun is what we call a 'Main Sequence Star' - it is currently in the prime of its life, fusing hydrogen to helium in its core and releasing energy in the process. Stars spend the great majority of their lives as Main Sequence Stars - shining relatively steadily. However, all Main Sequence Stars gradually get more luminous as they age. The Sun is thought to be about 30% brighter now than when it formed, 4.5 billion years ago. That fact has actually caused a lot of debate over the years due to something called 'The Faint Early Sun Paradox' - which basically asks how the Earth was temperate and warm back then, if the Sun was much fainter! Part of the answer to that is that the Earth's atmosphere was a much more efficient greenhouse back then - more Carbon Dioxide, more Methane etc. - and so that acted as a blanket, keeping the young planet warm at night.

The problem, though, is that the Sun is continuing to brighten, and eventually, the Earth will warm to the point the oceans boil/evaporate. The last study I saw said that would happen in something like 500 million years time, though the exact timing is still up for debate. At that point, the Earth will heat rapidly - without rain/water driven weathering to pull carbon dioxide out of the atmosphere, the greenhouse will ramp up, and the Earth will end up like Venus.

Will that be the end for life? Well, I don't know if that would be enough to kill the deep biosphere - the stuff four kilometers down - that's a question for the awesome biologists in this AMA. But things are going to get worse for the Earth, in the long run.

Further in the future - probably in about seven billion years - the Sun will come to the end of its life, swelling up to become a Red Giant star. At its largest, it will engulf Mercury and Venus - and will come perilously close to devouring the Earth. The currently accepted theories seem to suggest the Sun will stop just short of eating Earth - but even if things don't go that far, the Sun's Red Giant phase will be catastrophic for our planet. The temperature will go through the roof, and our atmosphere may well be stripped away, leaving Earth a burnt, air-less husk.

Then, the Sun's life will come to an end. It will shed its outer layers, blowing them out to the depths of space - leaving behind a glimmering ember - a white dwarf star. That 'star' will be about the size of the Earth - albeit one containing around half the Sun's mass. The loss in mass will cause the remaining planet's orbits to spiral outward, adjusting to the reduced pull from the Sun - and if that doesn't destabilise things, then the Earth will orbit forever more, into an inky black eternity. The white dwarf, the former core of the Sun will gradually cool, from blue to white, white to yellow, yellow to red, and then fade to black. The Earth will be frozen - a surface temperature well below 200 degrees below freezing.

I actually wrote a piece for the amazing research news/views website The Conversation about the fate of stars like the Sun - which includes a fantastic animation that one of the editors made to accompany the piece. You can read it here, if you're interested: https://theconversation.com/curious-kids-whats-going-to-happen-to-the-sun-in-the-future-will-it-explode-78029

Of course, that's all assuming that the Earth isn't smashed into in a giant collision - similar to the one that formed the Moon, back when the Solar system was young! Some models of the Solar system's future evolution suggest the orbit of Mercury could become unstable, sending it careening through the Solar system. If that happened, and Mercury and Earth collided, that would certainly be the end of life as we know it!

What made you become an astrobiologist and what is the most interesting part of your job?

MargaritaShir

[GL] Thanks for the question. I think I had two major influences when it comes to pursuing astrobiology: science fiction and science communicators. As a young kid, I was really into Star Trek and Star Wars and alien films and would build spaceships and alien worlds with my Legos. I would look up at the stars at night and ask the very natural questions of "are we alone?" and "is there someone else out there, maybe even looking back?". Programs on television like Cosmos and Nova and Discovery channel specials then fed my speculations by letting me know what scientists were studying about the possibilities for life out there. I read the book Cosmos when I was very young and have re-read it many times since. I suppose I continued following a career in astrobiology because I still have those same questions I did when I was just a wee little one.

Hi all, Thank you for this exciting session! My question is how can we define 'life' when we begin to search in the universe? Are you only looking for 'life' similar to the life on earth?

I read a science fiction called The three-body problem by Cixin Liu. The author explained Fermi paradox in his book. Because all the civilization needs to survive and expand, and communication seems not plausible, more advanced civilizations will directly destroy lower civilizations in case they develop fast and endanger them. So all the civilizations just choose to hide themselves to be safe. That's why we can not find any trace of other civilization. Do you think it is dangerous that we search for other life in the universe?

chacozhang

[GL] Hi and thanks for the questions. To the first part, we actually have had quite a hard time defining life. The current idea that life is "a self-sustaining chemical system capable of Darwinian evolution" seems fitting, but might be missing out on a lot of life as we don't know it (for instance, intelligent machine civilizations). Carol Cleland, a philosopher and astrobiologist at the University of Colorado Boulder, has rather argued that we should focus less on defining life and more on characterizing life in its varieties as we know them and then use that understanding to ask what life as we don't know it might be like. In the current realm of astrobiology, we're constrained in some ways to looking for life as we know it (similar to what's here on Earth), but we also try to be aware that there could be other forms of life out there. That's why we've shifted a lot from looking for plant and animal life and more to trying to understand the chemistry, geology, and physical characteristics of environments to look for signs of potential biological processes.

What is the lowest common denominator for life? At what point would you proclaim "we found life!"?

I mean most of us have been sold this meme of "space-people" who look a bit different but are in many ways, mostly human. I understand that life on Earth is fine-tuned to the conditions on Earth to a degree that even a small change in it could wipe out an entire species. With conditions wildly different from our own, could alien life be so different that most people wouldn't consider it to be "life" in the general sense?

Also, not a "science" question, but Human civilization always had a fascination with the "sky" and "sky people". In most cases, these (fictional) representations of extraterrestrial life were in many ways, "human". I mean all of our conceptions of "alien life" are ultimately based on life as we know it on Earth. We've never actually "imagined" alien life. If we do find aliens, would that even be what most people think of when they say "life"?

SevenTwenty720

[GL] It makes sense that our perception of what might be "out there" has evolved along with us and our understanding of our place in the cosmos. Although many of us make fun of the Hollywood aliens (two arms, two legs, a human-ish head, etc.), it makes sense that they're using the aliens in those cases to tell stories and relating those stories to the human experience. However, there have been some attempts in science fiction, in literature as well as on screen, to make aliens less human-like and more, well, alien. Still, it makes sense that we assume that larger multi-celled aliens (if there are others with cells and multi-celled beings) have some traits in common with us. The need to gain energy and to eat, the need to move about and interact with the environment, the need to reproduce, etc., are all things that we assume alien life might also do. However, as we often find, the truth can be much stranger than the fiction. That's why it's good to be aware of those possibilities in our own work.

Seems to me that the most likely explanation for the Fermi paradox is that intelligent species just don't survive long enough after they industrialize. It's basically a Pandora's box situation plus the natural disaster factor. For all we know we have already exceeded the median lifespan of industrialized species.

With that in mind it would seem that our best chance for detecting the signals of other species would be to maintain at least our current level of technology for at least a thousand years.

The analogy that comes to mind is ripples in a murky pond full of turtles. Turtles that come up for air (industrialize) only briefly are much less likely to feel the ripples of other turtles who did the same. But the turtle that stays up at the surface (survives) for a substantially longer period of time will realize after a while that they are not alone.

Sorry I don't have an actual question. Though I'd love to hear any thoughts on this.

uwjames

[BD] In the inventory of trillions of potentially habitable worlds in our galaxy and others, it is plausible that some planets support simpler life long enough to make it to complex, multicellular forms. However, those that also go on to support life with intelligence, language and technology may be rarer still. And those forms of life may not survive long enough or express the interest and commitment to search for other life in their neighborhood or look back and ponder their own beginnings. And such inquisitive forms of intelligent life may be separated by great distances of space or lengths of time. Given that we have had less than a century to search for life in the universe, send our own messages out, and work on models for our own beginnings, our presence on the "big board" of possible cosmic intelligence is hardly yet a blip. So while we may not be alone, it may be that we are surrounded with nothing more than worlds with a (still remarkable) complement of microbial communities, or a lot of world that have "died" or for which evolution found no path forward to complex, bigger forms.

The last point here is that according to James Lovelock in his last book "A Rough Ride to the Future" the Earth will, within a few hundred million years, pass across a sort of "terminator" beyond which the energy being output by our steadily warming sun will throw us into a runaway greenhouse effect. In effect we will "become venus". This will quickly quench the wonderful evolutionary paths of complex life: plants and animals, and throw the planet's microbiota into a retreat into the deep rocks, like perhaps a form of life on Mars (if it exists). This would be the circumstance for life on Earth until several billion years later the Sun expends its fuel, grows into a red giant, and consumes the Earth. If you plotted out the time for the total time for life on Earth it might come to a total of 11 billion years. If complex multicellular life on Earth was present for just over a billion years, it only accounts for 10% of that time. If humans exist for only one million years it is only one ten-thousanth of the total time for life on Earth. It is astonishing to think that we may be so rare a phenomenon in the universe. Perhaps this most awe-inspiring and humbling realization might encourage us to take better care of our world and not bring on that greenhouse effect prematurely. Ultimately our real purpose and a mission for humanity might be to preserve life and enable it a pathway forward, for millions of years into the future.

When Europeans encountered the native peoples, their diseases wiped out entire civilizations. How valid is the fear of contaminating the rest of the universe with our very human microbes and is anything being done to try to prevent this?

ChemPossible

[GL] Good question! NASA has an office of planetary protection for exactly that reason. It's their job to figure out not only whether we're risking bringing dangerous life and materials back here to Earth, but whether we're endangering other possible beings and other environments through our own exploration. It makes a lot of sense to be cautious, though we also don't want to be too cautious and lose the opportunity for exploration altogether. There are trade-offs there between what we want to do, what we can do, and what we should do. Most of our spacecraft are built in clean rooms and attempts are made to keep them as sterile as possible, though we understand that it's super difficult to get things entirely clean (microbes really are just about everywhere here on the surface of Earth).

Q: Do you ever get brigaded by FOIA requests?

I've read that scientists who research evolution sometimes get targeted by religious groups, and get buried by requests for information they have to provide because of their funding sources. Had this ever happened to you?

seanbrockest

[GL] That has never happened to me, nor have I heard of it happening to anyone else, though I can see how it might happen to some astrobiologists. We've had scientists studying evolution and ecology at the University of Colorado Boulder be targeted in various ways by some religious extremists. Although this is terribly saddening and frustrating, I think, in general, most religious people are also very interested (in a positive way) about astrobiology. There are lots of beneficial conversations we can all have about our own personal beliefs and our scientific explorations when it comes to exploring other worlds, searching for life, and considering our place in the cosmos.

Q: Do you ever get brigaded by FOIA requests?

I've read that scientists who research evolution sometimes get targeted by religious groups, and get buried by requests for information they have to provide because of their funding sources. Had this ever happened to you?

seanbrockest

[JH] As an astronomer, I've never had the pleasure of running into an FOIA request :) And that isn't an invitation to try! Astronomy as a field has actually historically been really good at making data public really quickly. Most research programs make all their data publicly available after a relatively short period - just recognising that the best science comes with the most data, I guess. I know that's going to be true for data we take with the MINERVA-Australis facility we're building here at the University of Southern Queensland. We'll have a period of one or two years where any given data we obtain is proprietary, then we'll make it freely available.

Fortunately, I think the work we do is really quite uncontroversial - which helps. There's no real suspicion we're hiding something (whenever we find anything interesting, we tend to shout it from the rooftops!) - so (hopefully) no cause to spam us with FOIA requests :)

We always hear about planets and satellites that *may* be able to support life, but cannot be explored further. Why can't we look to similar conditions on Earth or even simulate such conditions in a lab to see if they can support life?

SevenTwenty720

[GL] We actually do that already! There are lots of researchers in various labs who are re-creating and testing environments like those of Venus and Mars and even potential deep ocean environments like what might exist on Europa. However, the problem in so doing is that life on those other worlds, if it exists, may have had many millions or even billions of years to evolve and adapt to those environments. We can learn a lot about what's possible here in the lab, but it's still very helpful to go out there and explore those environments directly when we can. Also, some of us have traveled to places here on Earth where we think the systems are similar to what we might find on alien worlds. My research has taken me to the High Arctic to explore the formation of sulfur on top of a glacier and to consider the chemistry and the biology involved in making that sulfur and changing it into the various forms that we find there.

have we found life on any other terrestrial bodies apart from earth?

inzi27

[GL] Thus far, no. We've still got a lot more exploration to do in our own solar system before we conclude that there is no other life here besides what's on Earth, but we haven't found any other life yet.

Hi All,

Thanks for doing this! If we are going to settle down on another planet, I assume there are a couple of things that need to happen for us to be successful in the short term: creating proper shelter, finding water, etc. As producing meat is very energy intensive would this mean that the first settlers would probably (need to) be vegan, at least in the short term?

gvanbavi

[GL] Oh, that's an interesting question. There actually might be other ways for our early colonists of other worlds to get what we might call "meat" protein. For instance, they may be able to grow insects for a source of food, or they may be able to make "lab grown meat" from animal cell stocks that are fed with materials from their gardens or other extraction methods. However, I think it's pretty likely that our earliest explorers to other planets and to colonize other worlds (if we can and choose to) will eat a primarily vegetarian diet.

Thanks for taking the time to do this! Can you say what the current thinking is on the relationship between plate tectonics and life? Do we think life could get started on a world with a stagnant lid regime? And while we assume, for the moment, that life needs water, do we have any idea what extent of ocean would be a minimum for life?

Bowgentle

[MVK] Good question! Plate tectonics allows two things. Greater interaction of rock with water, and recycling of water and carbon into the mantle so it can be maintained over geologically long time periods. So a stagnant lid may be able to harbour life - if there is liquid water - but it may not be able to develop complex life - ie the evolution of eukaryotes from prokaryotes. As for an ocean. It turns out that oceans may not be the origin of life setting after all. The problem lies with making complex organic molecules way before you even get life. To get complex organics, you need wet-dry cycles, so there is a growing feeling that life started on land, in hot springs. Key here is not only their capacity for wet-dry cycles, but they have variable pH and chemistries. SO, stagnant lid planets can have water, and they have volcanism that can make hot springs. So, they can definitely have the ingredients for making life. Mars is a good example. It did not have an ocean (most likely), but it does have volcanoes and hot spring deposits. Thumbs up there.

With space exploration gearing towards the private sector especially in the USA do you think that private companies would get behind the astrobiologists and fund projects that have no financial value when such types of projects are typically done by government agencies? Is there a commercial appetite for exploring life in space?

coolndown

[GL] Oh definitely! Although much funding for astrobiology comes from governments and educational institutions currently, there is also a huge human interest in the questions that drive astrobiology. Institutions and groups like the SETI Institute, The Planetary Society, Blue Marble Space, and the Breakthrough Initiatives are all groups that have intense interests in astrobiology and fund some of their endeavors with funds from private investors and donations/memberships from enthusiastic citizens. I think we're only bound to see the public interest in astrobiology and the potential for private industry in astrobiology to grow. A big question then becomes if and how we regulate what private industries do if a consensus of people or governments have good reason to think the private initiatives endanger us or perhaps endanger other worlds and other life.

Hey guys, thanks for doing this.

Unsurprisingly there are a lot of questions. I have scanned the others and don't think this has been asked before here.

If there was non-carbon based life out there, which element do you think other forms of life could be built on?

I've heard silicon as a possible alternative although carbon is so much more versatile. What do you think? And how could these life forms be built?

Technokraticus

[MVK] its all about simplicity, and the most return on investment. So carbon wins because it makes the most complex molecules most easily. If carbon is common then that is what will get experimented with by nature. If carbon is NOT common, then other elements might fill some of that gap, such as silicon or sulfur. But there is no evidence that either of these make complex molecules that could form life.

In terms of geological studies, what is the latest discovery on our own planet earth that compels you to believe that there is sustainable life beyond this planet?

Barbzzz61

[MVK] Our studies on the oldest life on Earth - 3.5 billion year old rocks from the Pilbara of Western Australia - show that it inhabited hot springs, on land. This lends critical, real world support for models of life originating in "...warm little ponds...", as Charles Darwin so presciently predicted in 1871.

What is the closest we've gotten to understanding the origins of life?

I've also heard that life formed as soon as the conditions on earth allowed it to. What would this suggest for life on other planets?

shenny7

[MVK] I think we're getting closer every day. There is currently a paradigm shift in our understanding of the site for origin of life, from teh deep ocean vents to on land, in hot springs. We have an article on this in August Scientific American - check it out! And yes, conditions on Earth supported life very early on and that is exciting for places like Mars that had an early, wet history that was short lived, but it could have led to life developing there - all the right ingredients!

What is the closest we've gotten to understanding the origins of life?

I've also heard that life formed as soon as the conditions on earth allowed it to. What would this suggest for life on other planets?

shenny7

DD Research on the origin of life is still a very young field with just a hundred or so scientists who have the resources to study the problem. This means that there are multiple competing ideas, and none of them yet accepted to be "closest", but if you would like to see what we think take a look at our article called Life Springs in the August Scientific American this year. To answer your second question, it seems likely to me that microbial life could emerge on any habitable planet with liquid water, organic compounds and an energy source. Whether it gets all the way to intelligent life is unpredictable, but it did happen at least once!

Assume that Venus once had life before her oceans boiled away. In this scenario is there any way it could ever be proved or would any possible evidence be long gone?

SenorTron

Did Venus' oceans boil away or were they never condensed? Big difference. But a good question. If there were oceans, it may not have been that important unless there were exposed land surfaces, as well, because it turns out that life most likely started on land and not in the oceans as many have thought. This is because to get complex organic molecules in the buildup to life, you need wet-dry cycles and this is impossible in the oceans.

What are the most common misconceptions about Astrobiology?

UnderTheSpinLight

[JH] Hmmn - I've been asked if I'm an astrologer any number of times, does that count? :D There are also people who think we study UFOs - I've had that one a few times too :)

More generally, I think people don't realise just how multi-disciplinary the field is - if you go to an astrobiology meeting, you aren't just talking to astronomers, or biologists. To really get to grips with the possibility of life elsewhere, you need people from all the sciences - so chemists, physicists, geologists - everyone can get involved :) It's a fascinating field - and the most interesting questions are those that none of the traditional scientific disciplines can answer on their own. And that makes it hard - so much of the language we use is contextual - and that context (and the language) varies from discipline to discipline. So we have to be very careful to make sure that the language we use is clear and our colleagues can understand it - trying to avoid jargon, or discipline-specific terminology. It's hard, but very, very rewarding!

How much, if any, evidence is there that life exists on other planets?

josephalbert7597

[GL] Currently, none. We don't yet have any evidence that alien life exists out there. What we do have, though, is evidence that there are other environments that may have been suitable to life in the past or may even be suitable to life (as we know it) now.

What is the best evidence found so far that would support the idea of there being life on another planet?

rbj8611

[MVK] water + rock + heat. The discovery of hot spring deposits on Mars shows these ingredients were present there in the past. Carbon and oxygen are everywhere, so there is a very real possibility that life arose on mars and many other elsewheres.