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EPISODE TITLE

Are We Alone Out Here? Examining the Recipe for Intelligent Life in the Universe

PODCAST SUMMARY

Dr. Jan Cami joins the podcast to discuss the origins of life on Earth, the process of finding other Earth-like planets, and the likelihood that we will ever find company out in the Universe.

INTERVIEW

You're listening to the Western science speaks podcast. Presented by Henry Standage.

Henry Standage 0:00
I think sometimes as humans, we see ourselves as very separate from the rest of life on Earth. Is there any grounds for doing so when comparing life, say genetically?

Jan Cami 0:12
That's an excellent question, so if we think about it, we are, of course, all genetically, very much related. So, if you take any two people on earth, you find that genes might, say 99 and a half or 200%. But we also have about 18% or so in common with life forms, we wouldn't immediately expect to be related to things like yeast and that sort of stuff. And so, humans have about 24,000 genes, and 355 of those we share with all life on Earth. Whether that's, that's microbes or that's blends of animals. We share those 255 genes minimum. And so what's biologists have done is kind of group that's like, if you take those species, which were most closely related in terms of like genetic makeup, chimpanzees, for instance, those are closely related to us, you can make something that's called a phylogenetic tree of life, where one of the end branches, that's where we humans and other animals actually are. And as you go further away towards the root of that tree, you get to more primitive life, as all the other life kind of kind of as the offspring of that proof of life. And so we think that there is this concept of this last universal common ancestor, which is a life form that had those 355 genes. And so, from that life form, all current life on Earth evolved. So yeah, Luca, we call them the last latest universal common ancestor. That's not necessarily the first life form on Earth. But that's the latest one for which all life further developed. So, we got to work out timelines of, you know, all those relations and time for genetic change. How far back would that latest universal common ancestor have lived? You'll find it's about a three and a half to 3.8 billion years ago, which coincidentally is about the age of the oldest fossils we can find. And so, so interesting as well, is that we have genes and Gene Expressions, so we can now figure out was those 355 genes that all life has in common. What do those actually do? So, I figured out that those 355 genes, there's genes that allow you to metabolize molecular hydrogen. There are genes for like thermal filmic behaviors, which means that that life could survive well in warm places. And so, you know, from that sort of properties this idea is born that life started in some warm water environments. Where that's like these warm little bonds that Darwin described, things like hot pools, hot springs, like you find in Yellowstone, or it's more like deep sea, volcanic fence, we call them black smokers. That's still up for

debate. But those environments kind of represents environments where it is warm, and that sort of life form probably could survive very well.

Henry Standage 3:41
Do you believe that LUCA? Is from the water originally?

Jan Cami 3:47
Yeah, we think that's most likely yeah. Because there's this idea that before you get into, say, biological species, there's kind of a chemistry leading up to that biology. And for a lot of chemistry, you kind of need a solvent to kind of get things to work. And so, yes, we think that certainly, it's a lot easier to kind of get towards living things in water than it is on dry land.

Henry Standage 4:16
Right. And I mean, we're talking about a planet that's four and a half billion years old. And we've only been around in our current form for a couple thousand years. How long did it take for primitive life to arise on earth?

Jan Cami 4:30
Yes, so that's actually a very surprising topic. And the truth is that we're not entirely sure of this yet. So, the oldest fossils that we found we are about 3.5 to 3.8 billion years old. But those do not necessarily represent the first life so life may have existed earlier. And there's a piece of controversial evidence in Zircon crystals, and those we know are actually much older. And there's some evidence for carbon that was produced by some biological process. It's not the most rock-solid evidence. That's why there's some debate about it. But if that would be true, the whole early history of the Earth is kind of interesting. You form the earth and within a few hundred million years you actually have oceans on the earth. And almost immediately after that you would have life. And if that's true at that time, we had lots of impacts from asteroids and comets that hit the Earth, as all of those impacts were like, like extremely energetic, energetic enough to actually make the entire oceans boil off. So, we don't think that primitive life would have been able to survive that or maybe they were able to survive. But if these events happened, and they did not survive then life reformed again, fairly quickly, as well. And so, there's this this idea that, you know, if life happens very quickly on earth or it happens even multiple times within a few hundred million years, which astronomically speaking is like the blink of an eye. Right? Then it suggests that the whole process that brings us to living things may not be that difficult. And that is very different. If you look at the intelligent life, it takes way longer to develop intelligent life. Where there's of course, questions about like, how do you define intelligent life to begin with? But if we would see ourselves as an intelligent species that takes four and a half billion years, and so arguably, it's a lot harder to make an intelligent being than it is to make like a single celled organism.

Henry Standage 6:44
Why is it that intelligent life took so much longer to develop than just primitive?

Jan Cami 6:50
Well, that's a good question, and I wish we had the answer. But what is certainly part of that is that conditions were probably not right. But that's all speculation because we don't really know whether you need conditions to make intelligent life or intelligent life is something that would happen. One of the arguments that you often hear is that, you know, if there wouldn't have been this asteroid that slammed into the earth 65 million years ago, chances are the dinosaurs would actually still be roaming around here. So, we don't know whether that's really true, what the dinosaurs would have - what if that impact

had not happened would the dinosaurs still roam here? Would mammals have developed with intelligence? It's kind of hard to say, we only have one sample size of one. And that's, that's where we are right now. So we don't have the answer to that question.

Henry Standage 7:40
What are the two common ideas regarding the development of intelligent life?

Jan Cami 7:45
Right, so actually, for both life and intelligent life, it's actually very similar and so the big problem I mean, the honest answer is we really don't know. We don't know because we only have a sample size of one for both life and for intelligent life, in essence, but here's the whole idea. So, if you look at the early life, well, that happened quickly. So maybe that means it wasn't all that difficult maybe then to ask for special conditions. And if that's the case, then you know, life is going to be plentiful in the universe, there's going to be life everywhere. But if you look at the intelligent life that took way longer to develop, and it's not that there were like, no evolutions to other life forms, right? We've had the Cambrian explosion, that sort of thing. So, there's been lots and lots of life forms in those four and a half billion years. It just took very long until one of those and other being intelligence. So that then suggests that there's steps in this process, which either are more complicated or less likely, and so then it would be more difficult to make intelligent life. And if that's true, which again, we don't really know, but if that's true, that's what that actually means. That the probability for finding intelligent life elsewhere in the universe, would be smaller. And so, either life is exceptional, because you need special conditions to create life or intelligent life is special, you kind of need exceptional conditions to create intelligent life, or it's actually unavoidable. It's just a matter of getting the rights conditions.

Henry Standage 9:17
Inevitable.

Jan Cami 9:18
Yeah. And so the universe is so big if it's just a matter of getting the right conditions, if, if they happened once on Earth, the universe is so big that there's bound to be places where those conditions happens again, or happened at the same time or before even so.

Henry Standage 9:32
I think a characterization we make a lot is that if there's primitive life out there, they'll want to annihilate us but if they're intelligent, then they'll be pre naturally disposed to, you know, wanting to collaborate with us. But we never think about what if they just want to annihilate us and they're super intelligent. Or maybe I've seen too many movies. That's option C.

Jan Cami 9:57
Yeah, well, I'm not too sure. About either of those. And it depends a little bit already on how you define primitive life. And so, you know, defining life and defining intelligence is actually surprisingly difficult. And that's the first part of the problems. I think but of course, no evidence for it. I think that life itself will actually be widespread and abundant in the universe, because I think this is chemistry leading to biology. And so, chemistry is just like cooking, right? It's, if you follow the recipe, you put in the same ingredients, you follow the same process then the same end result is going to come out. You know, if you put a pizza in the oven and you wait, what's going to come out is not a stuffed turkey. It's going to be a pizza that's going to come out. And it's the same for the steps that lead from chemistry to biology, if all that is essentially just some process. That just depends on the conditions that life is going to be

everywhere. But that's primitive life. So that's like single celled species like microbes. And so now you can wonder, like, are those going to be out to kill us? Well, not necessarily. But of course, they will have developed to adapt to their environments. And maybe that has implications for our health if we would come in contact with them.

Henry Standage 11:21
So, in this analogy, the kitchen is a planet or an atmosphere similar to Earth. So, you think rather than trying to find intelligent life that developed in different circumstances, we're probably trying to find a planet that's the most comparable to ours.

Jan Cami 11:39
Yeah, and perhaps somewhat surprisingly, those are not rare planets. And so, we often hear like, oh, but you know, you guys, you only think about carbon-based life forms and you only think about like, like planets with water. And of course, that's not really true. We do consider other things as well. But carbon is abundant in the universe. And it's an element that easily makes these very complex and diverse species. So, it's an ideal element to use for, like a survival of the fittest sort of chemistry already. Water we find everywhere in the universe. So, finding a planet with water on it is probably not going to be unlikely there's going to be lots of places that have water on their surface. And so with what we know about planets around other stars, the numbers right now is that that we estimate that there's, you know, give or take a few billion there's about 40 billion earth-like planets, so planets that are rocky planets, maybe bit smaller maybe bit larger than the Earth, but rocky planets that are in what we call the habitable zone around their star, which is a region where the temperature is right to have liquid water on the surface and have to hold to hope that it's all steam not too cold as or ice. We can have liquid water on the surface, and we see water in every nook and corner of the universe, chances are that a good fraction of them actually will have water on them. So, it's actually not a stretch to kind of kind of focus on those first because we think that those will be plentiful. And if the same processes happened there that happened on the earth, then it's not unlikely that life originated there, too.

Henry Standage 13:26
How generous are we with the term Earth-like when we're looking way out and trying to find planets similar to ours? Because I think a lot of people don't really know what Earth-like means when we say that.

Jan Cami 13:39
So yeah, so right now we can actually be very, very approximate. So, I should say so right now, when you hear astronomers say Earth-like planets, essentially what they mean is as plans made of rock and metals, very different from planets like Jupiter and Saturn which are primarily made of gas. So when we say Earth-like planets, we mean rocky planets that have a solid surface that are about the size of the Earth maybe bit smaller or maybe bit bigger up to maybe twice the size of the Earth or something but not bigger than that. That's what we kind of now call Earth-like planets. And they can look very different than the earth because if their closer to their star they could be like super hot, far away they could they could be completely frozen. But by now saying look let's make sure they are in this habitable zone. That makes it a bit more Earth-like again in terms of the temperature that we expect. Are we really going to look like the Earth in terms of like having oceans and having an atmosphere, we don't know yet so future space missions will hopefully tell us. We're not quite there yet.

Henry Standage 14:51
Astronomers sometimes talk about Cosmic Origins. What does that mean?

Jan Cami 14:57
right that essentially means that our roots are in space. And it's a few kinds of slightly different meanings kind of in the very general sense, all the what we call heavy elements in your body. So, everything which is not the hydrogen, which is not the helium, was made in stars. And, and it's kind of interesting to think about this. So, carbon is made on the inside and of stars. So what makes star shine is the disperse of nuclear fusion that will make elements like carbon, those are brought to the surface and then at the end of their life, a supernova explosion or a slightly more gentle way, they actually kind of kind of expel all those elements back into space where they're now incorporated in the next generation of stars. And so, the carbon atoms in your left finger and your right finger may have originated from different stars, but they come from stars that carbon was made on the inside of stars. And that holds for every element in your atom and your body, which is not hydrogen or helium. But I think there's like a second layer to that term of Cosmic Origins, which relates to the formation or the origins of life. It turns out that there's certain complex chemicals, molecules that are easier to make in space, sometimes on the Earth. So we see, for instance, if you pick up some carbonaceous meteorites, you can bring them to the lab and analyze them for content, then you see that in some of these carbonaceous meteorites, you find 70 different kinds of amino acids. And now we need amino acids in our bodies to function. Those meteorites contain all the amino acids that life uses on Earth. Life on Earth uses only 20 of those and so all 20 types of the amino acids we find in meteorites, and so today, you know, there's about 1000 to 10,000 tons of space rocks that fall onto the earth. But 4 billion years ago, it was like many times more than that. And so, you bring in a lot of that organic material, which already is, has a level of complexity that you don't have to build. So, if you bring those in, you don't have to build these amino acids on the Earth, you have them available. So that might kick start life on Earth. And so that's the second meaning of what these Cosmic Origins are. We think that stuff made in space kind of helped kickstart life on Earth.

Henry Standage 17:30
I think that's such an interesting point. Because, for one, it gives me a better appreciation of what life means, the fact that these meteorites can carry something as essential as amino acids. And two, it makes me think about Earth as a blank canvas when it started, something that the ingredients had to come to it and then it began to sprout.

Jan Cami 17:52
Right there's also there's been some suggestions about you know, something called panspermia, where essentially the whole idea is, you know, life itself was brought in from space. So, you have like bacteria or microbes that are brought in, in meteorites to the Earth. We essentially have zero evidence for it. So, we do know that that some organisms are, you know, they can survive space like conditions, but we have not found any life or any life forms in meteorites. So, it's, it's, I think, at this point, speculation, it's maybe not impossible, but essentially, there's no evidence for that yet.

Henry Standage 18:38
Okay, I'll get to the big question, then. How likely do you think it is that there is life on other planets? And how can we even go about assessing that?

Jan Cami 18:48
Yeah, so that's a question that people have been struggling with for a while. And so, unfortunately, despite many years of research, the answer is still well, we don't really know so the scientifically honest answer is we don't know. And there's no clear way to know at this point. But you know, we can we can

make some assessments and maybe some guesses. And so, if the origins of life is essentially based on chemistry, then we think the consequence of that must be that life must be widespread and abundant. Because we see that the same ingredients are present throughout the entire galaxy. Well, throughout the entire universe. We see evidence for complex carbon-based molecules out to a redshift of six or the universe was like really, really young. So, we know that those complex carbonation species already formed pretty early on in the universe. So those ingredients are everywhere. The water we see everywhere, the planets we see everywhere, so we think the conditions and the ingredients are there. So then primitive life should exist on lots of water plants as well. How can we actually guess? Well, so there's a famous equation called the Drake equation. So, for one it's, it's not a physics equation, it's the description of like, it’s an equation to kind of kind of make an inventory of our ignorance in the whole process. It's essentially an equation that if you fill in all the terms, it will give you the number of the number of advanced civilizations in the galaxy or in the universe that we could be communicating with right now. And there's large number of terms in that equation. It starts with the number of stars that our galaxy forms per year, and then that's the fraction of stars that have planets. There's the number of planets per star then it's a factor which is the fraction of planets where life develops, then the fraction of life bearing planets that develop intelligent life and the fraction of intelligent civilizations that developed communication, and then there's the lifetime of the civilization. And so, the nice thing about the equation is that we actually don't know the terms very well. So now that we have kind of counted, like how many stars have planets, we now know that pretty much every star has a planetary system. So, we know that the product of the first two thirds now is about is about death. So that's the only thing that we know. But now the fraction of planets where life develops like math, we don't know, we have a sample size of one so is that the fraction, which is close to zero percent, or a fraction, which is close to 100%, or somewhere in between? We don't really know. So, what people do is they make some estimate based on their own gut feeling sometimes. So, it's, there's very little science to guide you on what that number should be for any of those. So depending on what numbers you put in, and maybe whether you're an optimist or a pessimist, you can actually get a very low number, a number of civilizations far less than one, which that would imply that we're the only technologically advanced civilization in the Milky Way galaxy. Or you can also by putting in larger numbers you can get like thousands or 10s of thousands of civilizations in the galaxy as well. So, we don't we don't know at this point what some of these factors are. And the only way to know some of them is to actually go and search for civilizations that we could actually communicate with. So, listen for their signals and try to find those. That's going to be the only way that we're actually ever going to figure out some of these terms. And so people think that we have been doing this for a very long time and like, gosh, you know, we haven't we kind of listened to all planets in the Milky Way galaxy yet. And the answer is no, we're very far away from being at that point. So, in effect right now, we're going to kind of look at It's the number of stars or planets where we have actually kind of listened in for signals. It's equivalent to kind of taking a glass of water going to the ocean, scooping up a glass of ocean water and then evaluating is there any fish in the glass? No, well, therefore there's no fish in the oceans. That would be wrong. But that's kind of what do we have now, we've kind of surveyed a very small fraction of planets in our Milky Way galaxy, we have not found any evidence for a civilization. But that does not mean that there is nothing out there. And so the only way to get some confidence in what those numbers are, is to kind of serve a much larger volume of stars in our Milky Way galaxy and do that exercise, because that's what we're doing right now. There are actually various organizations that are doing that. So, with the current rate of measuring year within say, two decades or so we should have found some signs of intelligence life that's communicating, or if we haven't found anything, then you know, we will have looked at millions of stars. And if in like 10 million stars that you've surveyed, you find zero evidence for theological civilization. It tells you something about what the product of these terms together is. And then that can help you to kind of gauge planets better, and what should be the number of civilizations in the Milky Way galaxy.

Henry Standage 24:24
What I like so much about the Drake equation is that you can measure your own personal optimism about how likely these essential factors to life are, and then get a basic sense of you know, how you personally feel and what the percentages that if you're correct, that they'll be life out there.

Jan Cami 24:41
It's one of those funny equations that's being used by people that want to use it, as proof that life must be abundant, but it's also used as proof by people who know life is not going to be abundant. And that's because of those factors or notes that you can put in whatever you believe right. So yeah.

Henry Standage 25:04
You explained that really well, I like the analogy of the glass of water in the ocean. I will say if if we did see a signal, would you be willing to go out there?

Jan Cami 25:15
Well, so that's a that's a totally different question. So, if life is out there, could we actually conceivably travel there? Or could they travel here? And so, one of the reasons I think that we haven't seen much evidence for extraterrestrials is that interstellar travel is going to be very, very difficult. And life forms like ours, I mean, we're not made to survive very long in those conditions in space. And so, with our current technology, traveling to the nearest star would take us 50,000 years. I mean, who's going to who's going to do this and how could you actually ensure that even as a civilization on that sort of trip you could actually survive for that long. So, I think that's not trivial. And sure, with technology we will probably make improvements to how fast we can travel. But then there's all sorts of other problems there, there is a maximum speed limit in the universe. And that's the speed of light. We're never going to reach that there's energy needs to reach that sort of speed which we're never going to meet. But also, once you start going at very high, high velocities, even small doses, grains will hit you at such a high velocity that they can actually do serious damage. And so, we know that interstellar space is full of dust grains, there might actually be kind of kind of rocks and boulders out there. So how can you avoid those if you're traveling at a very high speed, for instance. So, I think interstellar travel is always is going to be difficult. And so, the only way to kind of get around that is to make sure that you're not bound to kind of this, this biological shell that we have. And so, one kind of interesting.

Henry Standage 27:13
This is heading towards MIT right now. My faculty.

Jan Cami 27:17
Well, so one of the interesting things that people have been thinking about is like, like, what if you could upload your conscience to a machine, like artificial intelligence in a way, and of course, if you can put your consciousness into a machine that can actually self repair, then you're not bound to this, these problems that we biological beings have. And so, in that case, if civilizations get to that point, where they can have essentially self replicating and self repairing, I should say, robots, that ensure you put them on the spaceship. They don't care about 50,000 years.

Henry Standage 27:59

I can't remember the term and it's bugging me, so I'm just going to let it go. But yeah, we study this all the time in my classes.

Jan Cami 28:07
Yeah, it's pretty cool topic. Yeah.

Henry Standage 28:09
Yeah. I mean, it's definitely controversial. But yeah, the aliens might be a little freaked out by it when we come, what you're saying, it kind of sounds like we're destined to just be pen pals with them?

Jan Cami 28:24
Well, yeah, unless we find a solution to our, our, you know, biological constraints. And you know, but then you can start talking about artificial intelligence and then there's all sorts of other dangers involved in artificial intelligence. So, you know, if you build artificial intelligence, why would they care about going out and exploring? So yeah, I mean, t there's a whole set of other discussion points that's, you know, that sort of question opens up.