

UNIVERSAL LIFE DETECTION: ASTROBIOLOGY & ASSEMBLY THEORY



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STUART: The main problem, I think, is that we don't really know exactly what we're looking for.

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The only known source of life is on Earth. It could be that we have other life in the universe that's

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quite similar, but it could be completely different in a different environment. So, we wanted to come up

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with a way of looking for life that was kind of agnostic,

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where we didn't have to make any assumptions about life at all.

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COLE: In order to make any progress here, you have to think about,

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you know, what is it about life that seems unique relative to non-living systems?

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HEATHER: When you see something that is interesting that looks like energy went into it,

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that you can't explain through abiotic means, the best way, the most generalized way we could

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think of life, is being that extra push of energy that is needed in that environment to make that expression.

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A footprint is that little bit of energy in a dusty landscape that tells you

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something was alive there, but fossils are also a physical expression of energy that accumulated

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bunch of organic material. And we can do the same thing in chemistry by looking at the complexity

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of molecules and saying: is it likely that you would have all of that energy that it took to

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assemble a molecule in that way happening without the presence of life?

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STUART: What we landed on was basically a complexity measure. The further you go down chemical space,

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the larger molecules you make, the more decisions you have to make to get to that molecule,

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and the more possible other things you could have made. What we wanted to do was,

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we wanted to take molecules and say: how many steps would it take to make this molecule, even if you ignore

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all the rules of chemistry, in competition with all the other things that could have been made, and then use that

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how likely it is to have been made in a kind of just random process without biological direction behind it.

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HEATHER: You know, so this particular idea of molecular assembly was really born in math,

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even though it's a chemical method. It was born out of the idea of thinking about building molecules in an algorithm,

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and then, recognizing that molecules that are derived from abiotic systems have far less steps

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necessary to make them, than the molecules that we associate with biology, which take many more steps.

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COLE: So, once we sort of had that, Stu spent a bunch of time writing code so that we could calculate

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those quantities for any molecule we cared about.

The next step was to think about a way to measure it.

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The original idea of using mass spectrometry goes back to this thought experiment and knowing

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that NASA had this long legacy of sending mass spectrometers to space, and so, the first thing

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that we did was, we went and we got a bunch of molecules that had different complexities,

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different molecular assembly values, and we put these in the mass spectrometer and we looked to

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see how they broke apart, and we just counted the number of unique pieces they broke into.

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But, once you get that right, you can sort of see that the
higher the assembly number is, the more pieces

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the molecule tends to break into, which was
really exciting. Sort of the first time any of these

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chemical complexity measures has been something
that's detectable in an experiment in the lab.

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LEE: Now we have that framework, first
of all, we should apply it on Earth.

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Secondly, we should go around our solar system and
look for complex molecules everywhere.

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HEATHER: The MOMA instrument that will be aboard the ExoMars
rover has this capability of fragmentation,

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and then investigating the sizes and identity of
all of those fragments; and there will be a mass

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spectrometer that flies with Dragonfly to Titan
that will also be able to do that same process.

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COLE: I'm also really excited to go to Venus.
Well, I'm not going to go to Venus I don't want to die.

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But I'm excited that NASA is sending missions
there because I don't expect we'll find life there,

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but, I think we will learn a lot about the
scope of possible abiotic chemistry, so I think

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it'll be really good to visit the closest analogue
to Earth that we have, and I definitely think we

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should be using this technique to learn
about the surface of that environment.

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LEE: But, I think there's an even more important thing for
astrobiology; not just defining what life is,

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but also looking in, observationally, looking at
exoplanets. So, suddenly you can start to look

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for signatures over the entire universe using
spectroscopy remotely. But, of course, first things

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let's get some decent mass spectrometers
to Mars, Venus, Titan, Enceladus, and find what we

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can, what we can map, and that's really exciting. And I
think NASA is super excited and has been great