JGIota: A Surprise for Chloroflexota — The First Flagella!

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Allison: And now, a JGIota — a snippet about JGI-supported science. I'm Allison Joy, your host for this Iota.

Bacteria are among the simplest and most ancient life forms. So they're highly adaptable. They play essential roles in nutrient cycling, producing oxygen and breaking down organic matter. And the ways they do that offer valuable insights into how *we* might engineer new products for clean energy.

Today, we're talking about bacteria that make their home in hot springs — where temperatures and pH levels vary wildly.

Brian Hedlund: And so you get these really weird situations that you just don't find elsewhere on the modern earth.

Allison: That's Brian Hedlund, a microbiologist and professor at the University of Nevada, Las Vegas. He's been studying hot springs for over two decades, because of their extreme living conditions.

Brian Hedlund: And because of these weird conditions and weird chemistries, you get biology that does weird stuff. They're using weird chemicals that you're not going to find out in the ocean or soils.

Allison: Recently, he and Marike Palmer, a former postdoctoral researcher in Brian's lab, honed in on a group of bacteria thriving in these hot springs called *Chloroflexota*.

These bacteria have a lot of different tools in their various toolkits. Some *Chloroflexota* are able to break down toxic chemicals like those found in refrigerants or pesticides. Others can break down organic matter. They can respire both with and without oxygen. The list goes on. Here's Marike.

Marike Palmer: So these microbes that can actually respire these compounds — gives us a way to actually get rid of some of those toxic compounds. But at the same time, we have some that are really cool in terms of being able to at least break down some of the compounds that provide us with a means of making biofuels. So all in all, they're actually really diverse in terms of what they're able to do.

Allison: And part of that is because, remember — they're super ancient.

Marike Palmer: They're basically part of this group of bacteria they call the terrabacteria, which is thought to be those first bacteria that kind of colonized the land on early Earth. So it is kind of that movement from an aquatic environment, to more of a terrestrial environment.

Allison: That's billions of years worth of family history to trace. And we're still figuring out how different *Chloroflexota* evolved, to understand how they developed their weird tricks. And lately, while Brian and Marike were looking at samples from Great Boiling Spring in Nevada, something caught their eye. They managed to isolate an interesting organism.

Surprisingly, when they began to study the evolution of the new organism, they found that it was related to a group of *Chloroflexota* called *Dehalococcoidia*. And while Dehalococcoidia had been found in terrestrial environments like hot springs, these land-based Dehalococcoidia were sort of outliers. Because the vast majority of them are found in the ocean.

Brian Hedlund: And the *Dehalococcoidia* are really abundant and widespread in the oceans, but not — there are no cultures, and so there's a big, big mystery about these *Dehalococcoidia* in the ocean.

Marike Palmer: So there has been this constant debate on whether the marine *Dehalococcoidia* actually came from terrestrial ancestors or not.

Allison: So, in other words – did the *Dehalococcoidia* move from ocean to land, then back to the ocean? Or did they start in the ocean, and just stay there? Marike and Brian realized they were studying one of the *Chloroflexota* that could help settle the debate. It was terrestrial, and clearly an ancestor of the marine *Dehalococcoidia*.

Marike Palmer: And like, getting more representation at those deeper terrestrial branches in the evolutionary history of the lineage — kind of gave us more tools to be able to show that — yeah, you know, it actually looks like it's from a terrestrial origin and they actually migrated back to the ocean.

Allison: So the organism was indeed the ancestor of ocean-dwelling *Dehalococcoidia*. And as they looked closer at it, they found something… really surprising.

It had flagella, those little propeller-like tails that organisms use to swim around.

Marike Palmer: Up until now, the only motility that was confirmed in this phylum, in the *Chloroflexota*, is gliding motility, and that doesn't use flagella. So every single one of the cultivated *Chloroflexota* that we had until now, none of them ever exhibited motility. So none of them ever had flagella.

Allison: And that includes marine *Chloroflexota*. So for everyone keeping track at home, these new hot-spring *Chloroflexota* have flagella and can swim. Which, bizarrely, their marine descendants don't have. I asked Marike why that would be.

Marike Palmer: So it could be a case of the ancestor to those lineages just didn't have a need for flagellar motility any longer. And obviously maintaining a massive structure, a complicated energy-intensive structure like a flagellum would negatively affect you, if you don't need it in the environment that you find yourself in.

So that's kind of our best hypothesis for why they ended up losing the flagella as well.

Allison: Turns out, flagella are less useful in the ocean than you might think.

Marike Palmer: Many of the marine *Dehalococcoidia* are actually quite small in cell size, and the smaller the cells become, the less efficient, their flagellar swimming is because the Brownian motion would actually kind of, overpower their actual swimming motility. So they'll just be wasting energy trying to swim in a futile chase around their own tails, basically.

Allison: So it seems like when they moved back into the ocean, these *Chloroflexota* downsized a bit, losing parts of their genome, including the flagella-coding parts.

Brian Hedlund: But as a package, this idea that you're losing a bunch of DNA and you're streamlining and simplifying and that allows you to explode out into the oceans — there's some interesting experimental evolution or physiology, even studies of microbial fitness under different conditions — that I think could help us to better understand the underpinnings behind this evolutionary pattern that we're seeing.

Allison: Besides finding that flagella and helping settle the *Dehalococcoidia* debate, Brian and Marike also found evidence that these land-dwelling *Choroflexota* may have the ability to manipulate plant growth by synthesizing and degrading plant hormones.

Brian Hedlund: And so it could be that the root of the evolution of this stuff is interactions with plants. And they might even, in soils, be manipulating plant growth and plant stress — like, 'Hey, plant, don't be too stressed! But please grow so I can eat your stuff,' —

Marike Palmer: Yeah!

Brian Hedlund: But then, then they lost most of it, but not all of it, when they went back to the ocean.

Allison: And that is actually pretty fascinating, because understanding why bacteria need certain tools on land versus in the ocean — and exactly what they do with them — sheds light on how we might engineer tools of our own that harness the power of nature.

Allison: So that was Professor Brian Hedlund and his postdoctoral researcher Marike Palmer. The findings from their study were published in ISME Journal. We'll link to their paper in our episode description. Brian is a professor at UNLV, and Marike is now an assistant professor at the University of Manitoba.

The JGI enabled that work via our Community Science Program, which you can learn more about at jointgeno.me/proposals. You can also read more about Brian and Marike's findings on our website. There are links in the show notes — and an accompanying story, as well as a transcript of this episode online.

This episode was written, produced and hosted by me, Allison Joy. I had production help from Menaka Wilhelm, Massie Ballon, and Graham Rutherford.

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Thanks for tuning in – until next time!